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(Containing Papers read before the Society during 1910).

THE AUTHORS OF THE SEVERAL PAPERS ARE SEVERALLY RESPONSIBLE FOR THE SOUNDNESS OF THE OPINIONS GIVEN AND FOR THE ACCURACY OF THE STATEMENTS MADE THEREIN.

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[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. I., 1910.]

ART. I.—*On the Growth and Habits of Biporae.*

BY C. M. MAPLESTONE.

(With Plate I., Figs. 1 and 2).

[Read 10th March, 1910.]

In the collection of Polyzoa, dredged by H.M.C.S. "Miner" from a depth of 80 fathoms, about 22 miles outside Sydney Heads, which was submitted to me by Professor Haswell for examination and report, the most interesting were some conical forms of *Biporae*, of which three were new species, and a scrutiny of them shewed that they, in common with previously known species, differed considerably from other polyzoa in many points, especially in the arrangement of the individual zooecia composing a zoarium, their method of growth and the attitude of the zoaria when living.

My observations, however, point to very different conclusions from those expressed in a paper by Mr. Whitelegge in the Pr.L.S. N. S. Wales, 1887, page 387, et seq.; in which he established the genus *Bipora*, and included in it the following species:—*Lunulites philippinensis*, Busk; *L. cancellata*, Busk; *L. angulopora*, Ten. Woods; *L. incisa*, Hincks; *Cupularia crassa*, Ten. Woods; *Conescharellina depressa*, Haswell; *C. conica*, Haswell; *Eschara umbonata*, Haswell; and *Flabellopora elegans*, D'Orbigny; they being, he says, "a most distinct group having little in common with those with which they have been associated except habit and form." This last statement I must question, because as to their "habit" it will be seen from what follows that it is far from being known or understood, and as to their "form," the forms not only of the zoaria but also of the zooecia are so very different that I do not think they can possibly be assigned to any one genus, and the inclusion of them under the name of *Bipora* only adds to the perplexity that already exists in respect to them; I am not at present in a position to discuss this portion of the subject with certitude, but on a future occasion I may be able to offer a more

satisfactory classification of the species abovenamed, and the new ones described in my report upon the "Miner" polyzoa.[1]

After remarking that the structural features presented by the various species of this group are of such an exceptional character that it will be necessary to remove them altogether from the family *Selenariidae*, in which most of them have been placed, and that they appear to possess characters which are either unknown or rarely found in other species of Polyzoa, Mr. Whitelegge states that the "method of growth (not habit or form) or increase in size of the zoarium by the addition of new zooecia is intercalary, taking place on the surface between the cells already formed and not at the outer margin, as in most other polyzoa."

This view, I think, is incorrect. Intercalary zooecia could not cause any *increase in size* of the zoarium. There is a certain organic connection between all parts of a zoarium, but it is not such as would cause the zoarium to swell in size if new zooecia were intercalated among the others. From my examination of the various species I find increase in size is made on the margin of the flat, or nearly flat, species; consequently, as in all other disk-like forms, the zoaria grow from the centre to the circumference.

The conical *Biporae* grow from the apex to the base; I do not say downwards because I believe that, when living, the base is uppermost. A proof of the correctness of this opinion is shown in those zoaria which have the coral *Dunocyathus parasiticus* growing on, or out of, their bases; for it is impossible that they could rest upon them, because the delicate tentacles of the coral would be crushed, and the coral could not live under such circumstances. Among the *Biporae* dredged by H.M.C.S. "Miner" were a few with this coral growing on them, and through the kindness of Professor Spencer I have received some specimens of *Biporae*, dredged some 104 fathoms off the coast of South Australia by Dr. Verco, of Adelaide, in which the coral is imbedded in the zoaria, and also some sections of the same. The sections show the base of the coral to be sometimes far down in the zoaria, and that the zooecia formed subsequent to the commencement of the growth of the coral have grown up

1 Records of the Australian Museum, Sydney, vol. vii., No. 4, 1909, p. 267, et seq.

round the outside of it. Fig. 1 is a sketch made under the camera lucida of a section; it, however, is somewhat imperfect owing to the very brittle nature of the coral, but it will be seen that the coral started to grow upon the *Bipora* at a very early stage of the latter's existence. I have indicated the junction of the coral and the *Bipora* by a thick line. A characteristic pointing to the same conclusion is that in these conical forms the zooecia are, in almost every instance, in perfectly regular rows from the apex to the base, they very gradually increase in size from the apex to the base, and the zoaria preserve their shape throughout their growth—i.e., both the young and the old zoaria have the same angle at the apex.

As stated above, I consider the conical forms in their living state have the base uppermost. This would seem to be incredible, but in a postscript to his paper Mr. Whitelegge mentions he had had the good fortune to have had a living specimen of *Bipora philippinensis* (a nearly flat form living in Port Jackson) under observation for three days; and that from it there extended fine filaments, half an inch long, attached in some cases to tubes of Annelids and fragments of shell. He says the filaments appeared to grow out of an avicularium. This affords a clue to the manner in which the conical forms manage to live with their bases upwards. All of them have on the apex small avicularia and pores, and I consider that from these pores filaments similar to those recorded on *Bipora philippinensis* grow, and probably attach themselves to fragments of shells, etc., on the surface of the ocean bed, and so anchor themselves. Professor Harmer, in his Presidential address to section D. of the British Association for the Advancement of Science at Dublin, in 1908, stated he had some evidence that Selenariidae (in which the Biporae were originally placed) may be attached to ooze by means of very delicate, flexible rooting processes, and he has suggested to me that probably these conical forms are attached by a ligament to some foreign substance in the same way as *Parmularia obliqua*, McG., is, and that they hang downwards in the water. This is possibly the case, but the ligaments may be strong enough to permit the zoaria being sustained in an upright position, or in any position between the vertical and horizontal.

Mr. Whitelegge further states that most of the published figures of the zooecia are upside down. This is accounted for by the extraordinary circumstance that the zooecia are really upside down; indeed, he admits as much when he says "the direction of the zooecia is also apparently reversed," and he says that the free distal edge of the operculum is directed towards the apex of a conical form. The free edge of the operculum is directed towards the apex, but it is not the distal edge. The fact is that the operculum is hinged at the distal edge, and not at the proximal one; so that in these conical forms not only are the zooecia upside down, but the operculum is also upside down and in the specimens, in which the operculum is not preserved (both fossil and recent) the sinus is always in the distal margin of thyrostome and not the proximal one, as in other polyzoa of the family *Schizoporellidae* (in which Dr. MacGillivray placed the Biporae). To make clear what I mean by saying the zooecia are upside down, take the case of the other cheilostomes; the zooecia are formed one beyond, or above another, and the later formed ones rest upon, or are joined to the earlier formed ones with the proximal end resting upon or joined to the distal end of the preceding zooecium, and the thyrostome is situated in the distal portion of the zooecium with the operculum hinged at the proximal margin opening downwards. Now in the conical *Biporae* the zooecia follow one another in a somewhat similar manner, but the zooecia are in a reversed position; that is, what is the proximal, or lower wall in the ordinary cheilostomes, is in them the distal or uppermost, the thyrostome is in the proximal portion of the zooecium, and the operculum is hinged at the distal margin of the thyrostome opening upwards. The cause of this peculiar reversal of the ordinary arrangement is unknown, but Professor Harmer points out to me that it would seem to show "that the polypide bud while in a young condition might get twisted round 180 degrees in the zooecium." This probably is the case, but, before twisting round, the polypide bud must have in its growth extended itself to the end of the zooecium furthest from the older zooecia before turning round and developing into a mature form. Absolute proof of this cannot be determined until some spirit preserved specimens of living forms be

obtained, and that is a matter of some difficulty, because these conical forms are only found at depths of from 80 to 250 fathoms, and are so small that when dredged up that they might not be discovered in time to properly preserve them.

Another structure in these *Biporae* which has puzzled me, and also Professor Harmer, is the "semi-lunar slit" which Mr. Whitelegge considers to be the commencement of a new zooecium. He gives a very circumstantial account of it and its development into zooecia, but I have not been able to discover any instances of such development in any of the specimens I have examined. This "slit" he reports as being seen in all stages of its development in *Bipora philippinensis*, but in a slide which he sent me some years ago containing some 40 specimens of that species I could only find it on two small highly calcified fragments; though subsequently on a slide, lent me by the Curator of the Australian Museum since I examined the "Miner" polyzoa, there were several specimens of this species, in most of which the semi-lunar slit was present in what I take to be the perfect or complete state. (See Fig. 2.) I could not find in any of them an imperfect or younger form. These slits surround a nearly circular flap, the base of which is connected with the surface of the zoarium by a raised nodular process, and I consider it is improbable that such as are present in the specimens could eventually be continued, so as to complete the circle, through this thickened process, and cause the flap to fall off, and even if they did, the opening would not correspond in either size or shape with the ordinary peristomial orifice; and if, as Mr. Whitelegge states, there were underneath this external orifice an oral opening, it would indicate the formation of a zooecium considerably below the surface of the zoarium, in no way contributing to its "growth in size." Now if the theory that the semi-lunar slit is always the commencement of new zooecium be correct, it should be found in all the various species of *Biporae*. Mr. Whitelegge records it in *B. angulopora* and in *B. elegans* (in addition to *B. philippinensis* already alluded to), and states that it is *not* seen in any specimen of *B. umbonata*, in the Australian Museum, which is the species in respect of which he states Professor Haswell's description of the "different forms of the mouth" showed

the various stages of it; and also it is the species in which he says he saw the oral aperture underneath the peristome, which caused him to determine the name of the genus, for the reason that he considered the slit itself when completed forms the *peristomial* orifice, and as it is formed *before* the oral aperture, he assumed it to be therefore the *primary* orifice and the oral aperture the *secondary* one; and the occurrence of the *two* orifices caused him to name the genus BI-*pora*. It is important to note that he makes no mention of the occurrence of the slit in his descriptions of the other species dealt with in his paper. With regard to these "slits" I must confess that my reasoning depends a great deal upon what I may call negative evidence. It is to be regretted that Mr. Whitelegge did not illustrate his paper with figures, showing the various stages of development of which he speaks; so that it is extremely difficult to deal satisfactorily with the subject, and these "slits" must at present remain an unsolved enigma.

Another point of interest in connection with the *Biporae* is that up to the time of the publication of Mr. Whitelegge's paper there was no record of any ooecia having been seen upon any species of this genus. In his description of *B. philippinensis* he states that they are present in that species, and his description of them is, "external, globose, smooth, with a faint fimbriated stigma in front"; but he gives no figure. Many, if not all, of the specimens of this species which are upon the slide lent to me by the Curator of the Australian Museum, had ooecia upon them, and as I had not seen them before, I made a drawing of a portion of one zoarium, which is here reproduced (Fig. 2) as they have never before been figured. The ooecia agree fairly with the description, but I could not see upon them the "fimbriated stigma," though there was on some of them an irregular line apparently marking the limit of a layer of tissue or thickening in the walls of the ooecia. The ooecia are on the upper surface of the zoaria, which is slightly convex, and near the periphery. In order to obtain a view of the ooecial openings which are situated at the base of the ooecia, it was necessary to tilt the slide so as to expose the edge of the zoarium to view. Scattered among the zooecia are some of the "semi-lunar slits" spoken of above. I have drawn a

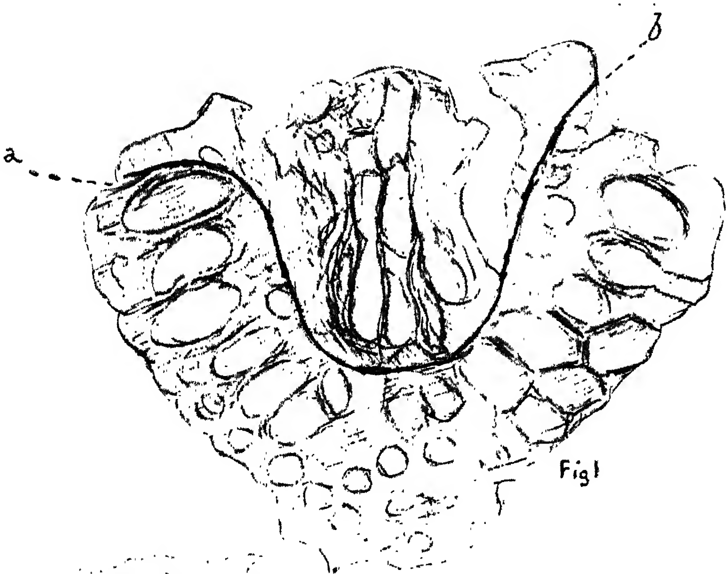

Fig 1

Fig 2a

Fig 2

small portion of the surface more highly magnified (Fig. 2a) to show their structure more clearly; it will be seen that the "raised nodular process" appears to be a means of strengthening the connection between the flap and the rest of the zoarium, and I think shows the improbability of the "slit" being continued, through it, into a circle, so that the flap would fall off.

There is yet another point I must notice here, and that is, that in the specimen figured the marginal zooecia have very large inverted funnel-shaped peristomes, and it is a question of considerable interest as to how these large peristomes become absorbed, or rejected, as there is no trace of them in the older zooecia. Altogether the *Biporae* exhibit so many abnormalities that they are well worth further careful study, especially if spirit preserved specimens of living forms can be obtained.

EXPLANATION OF PLATE I.

Fig 1.—Section of coral growing in Bipora, a to b, line of junction. × 26.

Fig. 2.—Portion of zoarium of Bipora philippInensis, showing ooecia and semilunar slits. × 60.

Fig. 2*a*.—Portion of same zoarium, showing a thyrostome, avicularia and a semi-lunar slit. × 106.

NOTE.

Since the above paper was written, I have received from Mr. G. M. R. Levinsen, of the Zoological Museum, Copenhagen, a copy of his "Morphological and systematic studies of the Cheilostomous Bryozoa," in which, with reference to the "semi-lunar slits" (which he terms "lunoecia,"), he says that the view that they are "rudiments of new zooecia" is quite incorrect and in complete conflict with his investigations on them, and that the idea that new zooecia can be intercalated between older in a well calcified Bryozoa colony is so improbable that he has "no hesitation in declaring such a process impossible."

[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. I., 1910.]

ART. II.—*On some Pselaphidae of the Howitt Collection.*

BY ARTHUR M. LEA.

[Read 10th March, 1910.]

Mr. Jas. A. Kershaw, of the National Museum, recently kindly allowed me to examine the following *Pselaphidae*, of the Howitt collection, bearing King's original name labels:—

CTENISTES VERNALIS, King (Trans. Ent. Soc., N.S.W., I., pp. 40, 102, 300).
RYTUS PUNCTATUS, King (*l. c.* pp. 103, 303).
R. VICTORIAE, King[1] (*l. c.* p. 304).
TYRUS HOWITTI, King[2] (*l. c.* p. 301).
BRYAXIS ATER, King (*l. c.* j. 309).
BYTHINUS NIGER, King (*l. c.* p. 312).
EUPLECTUS EXCISUS, King (*l. c.* p. 313).

All of these I re-mounted so as to examine the under surface and legs. As the original descriptions are extremely brief, more detailed ones may be acceptable to workers in the family.

Ctenistes vernalis, King (now *Ctenisophus vernalis*, King).

King's label, "Ctenistes vernalis, R.L.K. (Tmesiphorus vernalis), Paramatta."

Two specimens (sexes) from the original locality, and probably therefore co-types. They are certainly different to the species identified by myself (from comparison with the type, but without examination of the under surface), sent to Raffray under that name, and described by him[3]; and which species has the abdomen very feebly impressed in the male.

The supposed co-types exactly resemble that species on the upper surface, and have the antennae as in both sexes of that species, but the third ventral segment has a rather strong

1 Not *Tychus howitti*, King.
2 Not *Tyrus victoriae*, King.
3 Proc. Linn. Soc. N.S. Wales, 1900, p. 208.

transverse impression, bounded on the hinder margin by two distinct oblique obtuse ridges, which do not quite meet. From some directions the abdomen appears feebly longitudinally impressed from base to apex, with the ridges like two distinct and fairly distant tubercles. The spines on the under surface of the head are thin and acute.

The ventral impressions on the males of this genus are the most satisfactory characters for the identification of the species, and in King's descriptions are not even mentioned.

I believe the Howitt specimens to be correctly named, but the species of this genus so strongly resemble each other that King may have been mistaken, and it is very desirable that the ventral impression of the type should be examined and described.

Rytus punctatus, King (now *Rytus subulatus* King).

King's label, "Rytus punctatus, R.L.K. (Tyrus subulatus), Paramatta."

First described by King as *Tyrus subulatus*, but later mentioned as the type of the (then) new genus *Rytus*, but the name altered, without sufficient cause, to *punctatus*.

As the essential features of the species are re-described[1] by Raffray, there is no need to re-describe the Howitt specimen.

King recorded the types as from Parramatta and Dunheved; the Howitt specimen is from Parramatta; a co-type in my own collection is from Dunheved, and I have others from the Richmond River and Windsor.

Rytus victoriae, King.

King's label, "Rytus victoriae, R.L.K."

Type ♀. Reddish castaneous, head and prothorax darker, palpi and tarsi flavous. With rather long pale pubescence.

Head rather long, with small punctures, with a fairly deep fovea of moderate size close to each eye. Antennary tubercles fairly prominent. Antennae passing middle coxae, first joint as long as second and third combined, second slightly longer

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1 Proc. Linn. Soc. N.S. Wales, 1900, p. 239.

than third, third to eighth subequal, ninth larger and wider, its apex with a short connecting piece, tenth of similar shape but somewhat larger, eleventh ovate, the length of three preceding combined. Palpi about three-fourths the length of antennae, first (apparent) joint long and thin, but at apex suddenly inflated and subglobular, second not half the length of first, base thin, but rather strongly inflated to apex, third not much shorter than first, base with an inflated portion somewhat larger than that of first, thence thin to apex, but thinnest just in front of inflated part, apex with a short seta. *Prothorax* wider than long, greatest width near apex, thence regularly decreasing in width to base; with small sparse punctures. *Elytra* slightly wider than long; almost impunctuate, each with two basal impressions, one at base of a distinct subsutural stria, the other between it and side, with a short rearward extension, but too short to be considered a stria. *Metasternum* very gently concave in middle. *Abdomen* non-foveate. *Legs* edentate. Length, 2 mm.

Hab.—Victoria.

The specimen redescribed is certainly the type, as King stated that it was unique in the collection of Dr. Howitt. It is readily distinguished from *subulatus* by the feeble punctures. Raffray regards it[1] as the probable female of *emarginatus*, King[2].

Tyrus howitti, King (now *Tyromorphus howitti*, King).

King's label "Tyrus Howitti King."

Type ♂. Reddish castaneous, appendages somewhat paler. With pale, evenly (but not densely) distributed pubescence.

Head convex,, with dense and rather coarse punctures; antennary tubercles moderately raised. Antennae extending to middle coxae, first joint about twice as long as second, second slightly longer than third, the others to eighth very feebly decreasing in length, ninth distinctly wider, and longer than eighth, tenth still longer and wider, eleventh ovate, slightly

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1 Proc. Linn. Soc. N.S. Wales, 1900, p. 239.

2 In the synonymy he gives *emarginatus* as first referred to *Tyrus*, but this is incorrect.

longer than ninth and tenth combined. Palpi with first (apparent) joint long, basal half thin, apical half strongly inflated and subelliptic in outline; second about as long as inflated part of first and somewhat thinner, third slightly longer and somewhat thinner than second. *Prothorax* about as long as greatest width, which is about apical fourth, sides strongly narrowed to apex, and moderately to base, which is slightly wider than apex; with a feeble median subbasal impression; punctures as on head but rather sparser. *Elytra* distinctly wider than long, shoulders strongly rounded, sides rounded and increasing in width almost to apex; each at base with two small foveiform impressions, one at base of a strong subsutural stria, the other marking the base of a short impression, which is much too short to be regarded as a stria; punctures rather sparser than on prothorax. Upper surface of *abdomen* with small punctures; lower surface without fovea. *Metasternum* widely and shallowly impressed in middle. *Legs* rather long and thin; front trochanters each with a large truncated tooth; front femora each with a rather small but distinct subbasal tooth; front tibiae moderately curved. Length, 2 (vix) mm.

Hab.—Victoria.

This species was omitted from Raffray's recent generic monograph of the family, probably on account of their being a *Tychus howitti*, King (now referred to *Tyraphus*). It belongs to *Tyromorphus*, and in general sculpture is close to *cribratus*, but differs in being smaller and somewhat differently sculptured. In general appearance it is remarkably close to *Rytus subulatus*, but has very different palpi. The second segment of abdomen on its lower surface, appears to have a very feeble ridge across middle of apex, but this is invisible from most directions.

Bryaxis ater, King (now *Eupines atra*, King).

King's label "Bryaxis ater, R.L.K.," and a label "Dandenong" in another hand.

Type ♀. Black, appendages piceous brown, but antennae somewhat darker than legs. Almost glabrous.

Head smooth and without impressions. Antennae rather short, first joint fairly stout, second as stout as first, but much

shorter, third to ninth small, tenth short but strongly transverse, eleventh large and ovate. *Prothorax* lightly transverse, sides rather strongly rounded near apex, and gently decreasing in width to base; disc without impressions. *Elytra* slightly longer than wide, sides sub-parallel, shoulders rounded; finely striate close to suture, but not elsewhere. Apex of *metasternum* gently impressed in middle. *Abdomen* non-foveate. *Legs* non-dentate. Length, 1 (vix) mm.

Hab.—Victoria (Dandenong Ranges).

The species also occurrs in Tasmania, as I have the sexes from the Huon River, the female of which agrees well with the type. The male differs in having the metasternum strongly and widely impressed; second segment of abdomen very feebly impressed (scarcely more than flattened) in middle, and apical segment lightly curved at tip, so that from some directions it appears to have a small apical tubercle. On the type the two apical joints of antennae form the club, the tenth being wide but short; the ninth is also transverse, but could scarcely be regarded as part of the club. The male has very similar antennae except that the two apical joints are somewhat larger.

Bythinus niger, King (now *Eupines nigra*, King).

King's label, "Bythinus niger, R.L.K."

Type ♀. Castaneous brown, legs paler, antennae darker. Almost glabrous.

Head smooth. Antennae moderately long, first joint rather stout, second as stout as but shorter than first, third to eighth small, ninth distinctly wider than preceding joints, tenth larger and more transverse, eleventh ovate. *Prothorax* moderately transverse, sides widest at apical two-fifths, thence subarcuate to base, without discal impressions. *Elytra* very little longer than wide, shoulders rounded, sides gently rounded and increasing in width to near apex, finely striate near suture, but not elsewhere. *Metasternum* feebly impressed along middle. *Abdomen* non-foveate. *Legs* non-dentate. Length, 1 mm.

Hab.—Victoria.

Quite an ordinary looking *Eupines*. The specimen redescribed is certainly the type as King says "In Dr. Howitt's coll."

All that he says of colour is "niger," possibly the colour has somewhat faded (it is between 40 and 50 years since it was taken), but King appeared to regard almost all fairly dark browns as black. The club might fairly be regarded as three jointed, although the ninth joint is rather small; the eleventh is rather large, but not much wider than tenth. On each side of the head there are two very feeble impressions, invisible from most directions, one in front and one just above the eye.

There are before me two females and one male from Tasmania (Huon River) that appear to belong to this species. They differ in being considerably darker (a common occurrence with Tasmanian insects of all orders), with the impressions on the head still very faint, but rather more noticeable. The male differs from the female in having the club larger, with the ninth and tenth joints more transverse. Metasternum widely impressed and subcarinated on each side of middle. From some directions its first ventral segment appears to have a large semicircular excavation at apex, bounded on each side by a small distinct tubercle; from other directions both tubercles and excavation are indistinct. The apical segment has a small circular impression.

Euplectus excisus, King (now *Euplectops excisus*, King).

King's label "Euplectus excisus, King," and a label "Dandenong" in another hand.

♂ ♀ Reddish-testaceous, legs and palpi paler. Clothed with short pale pubescence; sides with a few scattered hairs.

Head with a deep fovea on each side, the two opening out and conjoined in front, so as to give the appearance of a wide semicircular impression, middle of base with a short longitudinal impression. Antennae just passing middle coxae; first joint as long as second and third combined, second globular, slightly longer than third, fourth to eighth short and transverse, ninth scarcely longer but distinctly wider than eighth, tenth slightly longer and distinctly wider than ninth, eleventh ovate, base truncate, almost as long as three preceding combined. *Prothorax* distinctly transverse, sides strongly rounded from apex to middle, then strongly and suddenly constricted, and

then appearing as a subtriangular extension on each side of base; with three strong, longitudinal impressions, and a deep transverse sub-basal one, the latter causing the lateral constrictions; with small scattered punctures. *Elytra* slightly longer than wide, shoulders rounded, sides gently rounded, each with two striae commencing in basal foveae, the subsutural one distinct throughout, the discal one distinct at base, traceable at apex, but obsolete in middle; punctures much as on prothorax. *Metasternum* feebly impressed along middle. *Abdomen* non-foveate. *Legs* moderately long; trochanters each with a feeble subtriangular node or tooth; femora edentate. Length, 1 4-5ths mm.

Hab.—Victoria: Dandenong.

The specimen redescribed is a co-type, if not the actual type itself, as King says, "The Dandenong Ranges Dr. Howitt." In general appearance it is fairly close to *Euplectops gibbosus*, but the prothoracic sculpture, although deep, is less profound, antennae somewhat shorter and stouter, with the joints of the club differently proportioned. Its clothing is also more noticeable. The abdomen has a short process projecting backwards from its tip, but I cannot make out whether it is an ovipositor or the sheath of a penis, but it is probably the latter, as the trochanters appear (from some directions) to be obtusely dentate; the third ventral segment also has a very feeble subtriangular impression at middle of apex, but which is invisible from most directions. The disc of each elytron is slightly paler than its other parts, but the shades of colour are not sharply defined.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910.]

Art. III.—*A Species of Argas, apparently new to Science.*

By GEORGINA SWEET, D.Sc. (Melb.)

(With Plate II.)

[Read 10th March, 1910.]

Four specimens of "Fowl-tick" handed to me by Professor Gilruth from a spirochaete-infected fowl appear at first sight to be the hexapod larvae of *Argas miniatus*, Koch, 1844, as figured by Salmon and Stiles (1901, pp. 405-7), which is now regarded by Nuttall and others in their recent "Monograph of the Ixodoidea" (1908, p. 8) as synonymous with *Argas persicus* (Oken), 1818. But on closer examination they are found to differ in several particulars from that form, especially in size, in which they more closely resemble *Argas vespertilionis* (Latreille), 1796, and in the more ventral position of the capitulum, in which they are unlike the larvae either of *Argas persicus* or of *Argas vespertilionis*, though very similar to the nymph of *A. vespertilionis*, figured and described by Nuttall (1908, fig. 50 and p. 37).

The proportionate size does not appear to be related in this case to the age of the larva, since the larva of *Argas persicus*, which is from .6 to .7 mm. long, and about the same in width, simply becomes longer as it matures; whereas three of my specimens are wider than long, the other circular, and all four much larger than the hexapod larva of *Argas persicus*. It is easily conceivable that *Argas vespertilionis*, the bat-tick, should be found on a fowl, but not only are these four specimens distinctly smaller than the larvae of *A. vespertilionis*, but they differ in several other points from the latter, as seen in the following diagnosis.

In view of the condensation of species of Argas by recent workers, I hesitate to found a new species in the absence of more material for comparison, but in order to avoid possible

confusion, it appears advisable to record these specimens as a new species—viz., *Argas victoriensis.* Efforts have been made to obtain more specimens of this form from the original source, but so far they have not been successful. All other fowl-ticks so far examined from Victoria, New South Wales and Tasmania, have been undoubtedly *Argas persicus* [c.f. Nuttall and others (1908, p. 21)].

Argas victoriensis, n.sp.

Diagnosis of Species.—Larva. Length 1.1 to 1.6 mm. wide, and .96 to 1.6 mm. long, hexapod, and generally a short oval, but sometimes circular in outline, quite flat. The capitulum is inserted ventrally, but in none of my specimens does more than the extreme tip of the hypostome project beyond the anterior edge of the hood, and as a rule only the tips of the chelicerae project anteriorly (contrast *Argas persicus* larva); the palps, however, may do so, up to three joints or articles being visible from the dorsal surface. The palps are .258 mm. long, and slender, the terminal article being much longer than wide. (Compare *Argas persicus,* and contrast *Argas vespertilionis.*) The width of the capitulum at the widest part of the base, i.e., posteriorly, is .186 mm. (contrast .160 mm. at this region in *A. persicus*). The length of the hypostome is .186 mm. (contrast .144 mm. in *A. persicus*). The integument has fine transverse parallel wrinkles. Intestinal caeca are well developed. No discs ("pits") are visible. The legs are long and similar to those of *A. persicus.* Twenty-six marginal hairs are present, extending right round the body and hood. In other respects this form resembles *A. persicus.*

Locality.—Northern Victoria.

ADDENDUM.

Since writing the above, I have received from Professor Gilruth a further supply of fowl-ticks, obtained from the Riverina. This included seven larvae taken from the bird in daylight, and also some adults, obtained from the walls of the

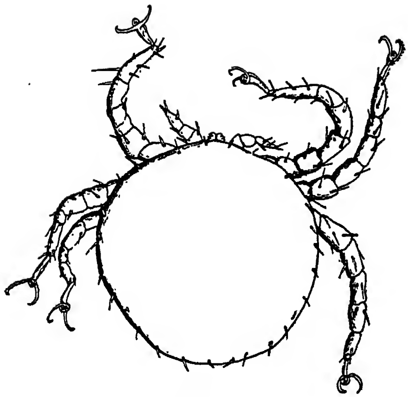


FIG 1

FIG. 3

FIG. 2

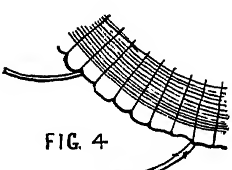


FIG. 4

fowl-house. The latter appear, so far as examined, to be indistinguishable from *Argas persicus*, but the larvae are undoubtedly similar to those described above as *Argas victoriensis*, n. sp. There is as yet no proof of any connection between these adults and larvae, although such may certainly be suspected—and at the earliest opportunity I shall endeavour to hatch out the adults from such larvae in order to test the point. On the other hand, the great difference in the chelicerae and hypostome from those described for the larvae of *Argas persicus*, points to the validity of this new species. Under the circumstances the following table seems desirable, showing individual width and length, and the character of the hypostome:—

Width	Length	
1.—1.1 mm.	- .96 mm.	Tips of chelicerae only, visible dorsally.
2.—1.3 mm.	- 1.3 mm.	Tip of hypostome visible dorsally.
3.—1.6 mm.	- 1.6 mm.	Hypostome and chelicerae not visible dorsally
4.—1.1 mm.	- .96 mm.	" " " " " "
5.—1.5 mm.	- 1.76 mm.	Tip of hypostome visible dorsally.
6.— .96 mm.	- .96 mm.	Hypostome and chelicerae not visible dorsally
7.—1.2 mm.	- 1.2 mm.	" " " " " "
8.—1.05 mm.	- 1.01 mm.	" " " " " "
9.—1.32 mm.	- 1.36 mm.	" " " " " "
10.—1. mm.	- .89 mm.	Tip of hypostome visible dorsally.
11.—1. mm.	- .93 mm.	Extreme tip of hypostome visible dorsally.

Nos. 5 to 11 are those referred to in this addendum.

Bibliography.

Nuttall, Warburton, Cooper and Robinson, 1908.
"Monograph of the Ixodoidea, Pt. I., Argasidae."
Salmon and Stiles, 1901, U.S. Dept. of Agriculture.
Seventeenth Annual Report, Bureau Animal Industry.

EXPLANATION OF PLATE II.

Fig. 1.—Argas victoriensis, n. sp.—Larva—dorsal view. × 20. Two posterior legs on left-hand side somewhat distorted in appearance through fore-shortening. The tips of the chelicerae only are seen at the anterior border.

Fig. 2.—Argas victoriensis, n. sp., Larva—ventral view. × 25. The three legs on the right-hand side are broken about the middle of their length.

Fig. 3.—Anterior border of a third specimen of same, showing chelicerae only, projecting in front of the body.

Fig 4.—Portion of integument, from posterior border of specimen of same, showing marginal quadrangular "cells."

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910.]

Art. IV.—*Notes on a Protozoon Parasite found in the Mucous Membrane of the Abomasum of a Sheep.*

By PROFESSOR J. A. GILRUTH,
D.V.Sc., M.R.C.V.S., F.R.S.E.

(With Plate III.).

[Read 3rd March, 1910].

The parasite was encountered during an investigation into the cause of a disease of the Braxy group affecting Tasmanian sheep, for which I have in a report to the Minister for Agriculture in that State suggested the name "Malignant Transudation." This parasite, however, appeared to have no pathogenic significance. It was encountered in sections of a portion of stomach wall, showing necrosis and ulceration, but in the comparatively healthy area.

To the naked eye, no evidence of its presence can be detected, at first sight, in the sections. Although situated in the mucosa, it does not cause any discernible elevation. It was, therefore, encountered purely by accident, and unfortunately only three sections out of a large number mounted show its presence.

Description.—A minute cyst, composed of a very delicate, faintly-laminated cyst wall, enclosing groups of sporozoites.

The cyst is somewhat oval, the long diameter being in the direction of the gastric glands. It measures 0.5 mm. by 0.3 mm. The contents consist of masses of small sporozoites arranged radially around a minute portion of residual protoplasm. Each sporozoite is about 4 to 6 microns long and 0.5 microns broad. Distinctly spindle shaped, with extremities tapering to a fine point, each is provided with a central oval nucleus. They are readily stained by the ordinary stains. Flagella cannot be definitely distinguished, although here and there certain sporozoites appear to be flagellated.

Nature of the Parasites.—At first sight one is struck by the similarity to colonies of Herpetomonas and to certain stages of the Malaria-parasite in Anopheles, but there is no evidence whatever of a blepharoplast or centrosome.

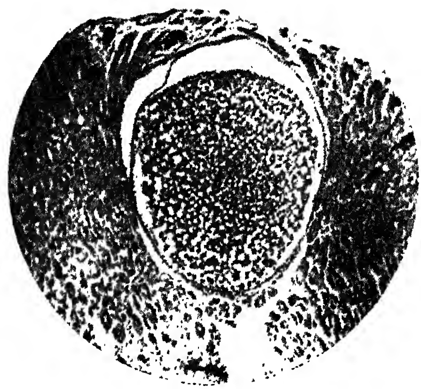
Dr. Mesnil, of the Pasteur Institute, Paris, to whom I forwarded a section for his opinion, agrees with this, but considers the resemblance much greater to certain stages of parasites of the intestines of some crustaceans, known as Aggregata. Indeed, he states that on comparing the two, "the resemblance is striking." As he suggests, it is more than possible that the parasite in question is a schizogonic stage in the evolution of some parasitic sporozoon of the sheep. Now as there is one sporozoon which is extremely common in my experience, not only in the sheep, but in cattle and pigs in Australia—viz., the sarcosporidium, the life history of which is extremely obscure, the possibility of its being a stage in its evolution is worthy of consideration. In almost every portion of muscle which I have examined microscopically in Australia, I have found some fibres affected with sarcosporidia. Their further study is therefore a matter of some economic as well of scientific importance. Unfortuntely, the minute size of the stomach cyst renders an investigation into the parasite mentioned a matter of extreme difficulty, but it should not be unsurmountable.

EXPLANATION OF PLATE III.

Upper Figure.—Section of stomach mucosa, showing cyst.
Lower Figure.—Groups of Sporozoites showing radiate arrangement.

POSTSCRIPT, 7TH JULY.

It is interesting to note that in a private communication received from Dr. Mesnil since the above article was read, he states that the cysts have now been found to exist in the fourth stomach of sheep slaughtered in the Paris abattoirs. His assistant, M. Chatton has made a very complete study of them, which will be published shortly.



[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. I. 1910.]

ART. V.—*New or Little-Known Victorian Fossils in the National Museum.*

PART XI.—ON AN IMPRESSION OF A BIRD'S FEATHER IN THE TERTIARY IRONSTONE OF REDRUTH, VICTORIA.

BY FREDK. CHAPMAN, A.L.S., &c.

(Palaeontologist to the National Museum).

(With Plates IV. and V.)

[Read 26th May, 1910.]

Introductory.

Fossil remains of birds, compared with those of other animals, are of rare occurrence. The reason for this is not far to seek. The bodies of birds, on account of their lightness of build, readily float, and are therefore more liable to disintegrate and decay before they can arrive at conditions tending to preservation by being sealed up in mud or silt. Moreover, their bones, with more or less easily attacked pneumatic structure, are placed at considerable odds compared with the more solid bones of mammals, or even of most reptiles. From such floating or decaying bodies the feathers soon tend to become detached; and these, also, have small chance of being preserved, unless caught amidst water-logged masses of leaves. Hence it is that most of the records of fossil feathers are from lacustrine, estuarine or shallow-marine accumulations, where they are generally associated with plant- and insect-remains. The rocks in which feathers have been found are for the most part of fine-grained texture, and comprise iron-stone, originally ferruginous mud or ooze, and gypseous and carbonaceous clays in the lacustrine series; and, more rarely, the inpalpable marly deposits of marine origin found in Bavaria (Solenhofen- or Lithographic-Stone).

Previously Recorded Occurrences of Birds' Feathers.

So far, the following appear to be the only instances of feathers having been found in strata older than sub-recent.

Upper Oolite.—Solenhofen, Bavaria (*Archaeopteryx*).

Eocene.—Green River Shales, Wyoming, U.S.A.[1]

Eocene.—Gypseous marls of Aix, Provence (*Strix*, *Alcedo*, *Upupa*, *Sitta* and *Turdus*, associated with plants, insects and fishes).[2]

Upper Eocene.—Mont Bolca, near Verona, Italy (*Ornitholithes faujasi* and *O. tenuipennis*).[3]

Upper Eocene.—Bournemouth. A small feather recorded from the plant-beds by J. Starkie Gardner.[4]

(?) *Eocene.*—Gypseous beds of Senegal.[5]

Lower Oligocene.—Freshwater Limestone of Limagne, Auvergne.[6]

Lower Oligocene.—Königsberg, Germany; in amber.[7]

Upper Oligocene.—Lignite beds of Rott, near Bonn, Germany.[8]

Upper Oligocene.—Two portions of feathers found by the Rev. P. B. Brodie in the Bembridge Limestone, Gurnet Bay, Cowes, I. of Wight.[9]

Miocene.—Freshwater Limestone of Croatia, Austria.[10]

Miocene.—Hard calcareous tufa of Hahnenbergs, Bernstein, Germany.[11]

Miocene.—Lacustrine marls of Florissant, South Park, Colorado, U.S.A.[12]

Upper Miocene.—Oeningen, Bavaria.[13]

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1 Zittel-Eastman. Text-Book of Palaeontology, 1902, p. 256.

2 Bayan. Bull. Soc. Geol. France, sér. 3, vol. i., 1873, p. 386.

3 Faujas. Ann. du Muséum, 1804, vol. iii., pl. i. figs. 1-3; Omboni, Atti Ist. Veneto di Scienze, lettere 1885, ser. vi. vol. iii.

4 Geol. Mag., dec. iii., vol. ii., 1885, p. 384.

5 See Zittel. Traité de Paléontologie (French ed.), vol. iii., 1893, p. 799.

6 Zittel. Loc. supra cit.

7 Zittel. Loc. supra cit.

8 Zittel. Loc. supra cit.

9 Geol. Mag., 1885, loc. supra cit.

10 Zittel. Loc. supra cit.

11 Zittel. Loc. supra cit.

12 Zittel. Loc. supra cit.; see also Bather (Proc. Geol. Assoc., vol. xxi., pt. 3, 1909, p. 159), for general conditions of deposit.

13 Scheuchzer. Physica Sacra, 1731-1735, pl. LIII., fig. 22.

Australian Bird Remains.

Bones of a struthious bird, *Dromornis australis*, Owen,[1] have been recorded from the Pleistocene of Peak Downs and the Paroo River, Queensland;[2] *Dromornis* sp. from the Mount Gambier Caves, South Australia, and Phillip Co., New South Wales;[3] and *Dromaeus patricius*, DeVis, from King's Creek, Darling Downs.[4] Numerous other remains, also from Pleistocene deposits, are recorded by the last-named author from the River Condamine, near Chinchilla, Queensland; chiefly referable to the Anseres and the Rallidae. Another extinct bird, *Genyornis*, allied to the Emus, has been described from the Pleistocene of Lake Callabonna, South Australia, by Messrs. Stirling and Zietz.[5] And lastly, Prof. Spencer has recently described an extinct species of Emu (*Dromaeus minor*), from sub-recent deposits in King Island, Bass Strait.[6] Nothing older than the Pleistocene, however, has been hitherto found in Australian rocks, so that the present occurrence of bird remains has a special interest.

Description.

In the specimens now described, the perfect impressions of the two sides of a feather have been preserved in an ironstone deposit of lacustrine origin below the Wannon Falls, at Redruth, Western Victoria. The two opposite halves of the ironstone block containing the impressions, accompanied by another, bearing numerous leaf-impressions, were forwarded to the National Museum by the Mines Department in 1893.

The feather is moderately long and curved; having a strong quill or rhachis. The impression shows that this rhachis was

1 Proc. Zool. Soc. Lond., 1872, p. 682. Trans. Zool. Soc. Lond., 1873, vol. viii., pt. 4. pp. 381-384, pl. lxii.; pl. lxiii., figs. 1, 2.

2 R. Etheridge, jnr. Rec. Geol. Surv. N.S. Wales, vol. i., pt. 2, 1889, p. 126.

3 Owen. Proc. Zool. Soc. Lond., 1877, pt. i., p. 95. R. Etheridge, jnr., Cat. Austr. Foss., Cambridge, 1878, p. 179.

4 De Vis. Proc. Linn. Soc. N.S. Wales, vol. iii., pt. 8, 1888, p. 1277.

5 Mem. Roy. Soc. S. Australia, vol. i., pt. iii., 1906.

6 Vict. Naturalist, vol. xxiii., 1906, p. 159. See also Mem. Nat. Mus. Melbourne, No. 3, 1910, p. 9.

flat, with a well-marked median channel near the base. It is also evident that the medullary portion contained large and irregularly disposed air-spaces. The lamellae lie close together, forming the vane; but occasionally cross one another, as if their cohesion had been destroyed by the damage of the web. The feather is nearly complete to the apex, and there is no appearance of an aftershaft or hyporhachis, such as is seen in the struthious birds. The lamellae curve upwards and outwards from the base of the quill, and are moderately long on one side and short on the other.

Length of feather, 73.5 mm.; greatest width, 20 mm.; width of web on one side of rhachis, 12 mm., on the other, 6.5 mm.; average width of lamellae, .75 mm.; thickness of quill near base, 1.25 mm.

Relationships.

The characters of this feather are not those of a struthious bird[1], there being no after-shaft present; and, moreover, the lamellae are not typically disconnected. In its general firmness of web, its length, slight curvature, and roundly acuminate apex, it suggests such a feather as may be matched amongst the primaries, especially the upper, in, for instance, the Black-billed Spoonbill (*Platalea regia*), or one of the Ibises. Of course, no clear identity can be established from the impression of a single feather; but the probabilities are considerable that, when the ancient lacustrine sediments of Victoria were laid down, some representatives of the long-legged wading birds of the order Herodii were living under conditions similar to those which they enjoy at the present day.

Associated Remains and Probable Age of the Beds.

On the same pieces of ironstone with the feather-impressions are some slender, cylindrical and pointed fragments, with fluted surfaces, which are probably portions of reed-like stems of

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1 See also Hutton "On Some Moa Feathers." Trans. and Proc N Zealand Inst, vol. iv. (1871), 1872, p. 172, pl. ix.

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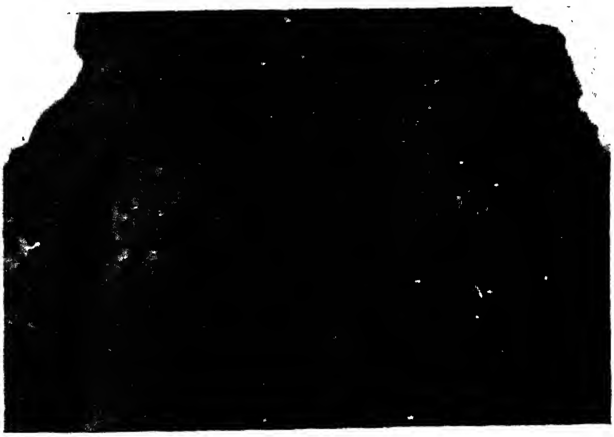
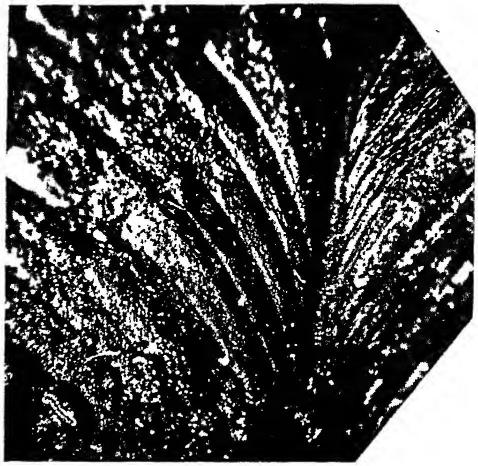


2

F.C. Photo.

Impressions of Bird's Feather and Eucalyptus Leaves in Tertiary Ironstone, Victoria.



3

4

F.C. Photo.

Impressions of Feather and Banksia Leaves in Tertiary Ironstone, Victoria.

plants allied to the rushes. Several fragments of long, ovate, pointed leaves on the same slab can, without doubt, be referred to the genus *Eucalyptus*. Their venation differs from those of the fossil species described by McCoy and Ettingshausen, in having remarkably long and sub-parallel secondary veins; and in point of fact, very closely agree with the leaves of *E. amygdalina*, Labill. The areolar interspaces formed between the secondary and tertiary veins are occupied by moderately large pustular oil-cells. On two separate fragments of the same ironstone bed there are numerous leaves of a *Banksia*, allied to *B. marginata*, Cavanilles, but having a narrow, parallel-sided ligulate form of leaf. The presence of a new species of *Banksia*, allied to a species now found living in the same locality, is interesting, as pointing to the same generic element in the flora of that tolerably remote period. And this, together with the occurrence of a *Eucalyptus* allied to the living *E. amygdalina*, proves that the characteristic flora of the "open forest type,"[1] had already become established. The evidence of marine fossils in ironstone bands above the older "gold-drifts" is in favour of a Janjukian or Miocene age; but whether this ironstone with terrestrial remains is a synchronous deposit can only be proved by further detailed stratigraphic work in the district whence it came. In appearance and general characters it closely resembles a typical ironstone of the Bacchus Marsh series with plant-remains; and also the Stawell ironstone deposit containing moderately shallow-water marine fossils.

In concluding these notes I must express my thanks to Mr. J. W. Audas, of the National Herbarium, who kindly assisted me in the comparison of the plant-remains here mentioned.

EXPLANATION OF PLATES IV. AND V.

Plate IV.

Fig. 1.—Impression of a bird's feather in ironstone; associated with leaves and stems. Redruth, Western Victoria. Nat. size.

1 See H. Deane, Rec. Geol. Surv. Vict., vol. i., pt. 1, 1902, p. 18.

2.—Opposite face of above ironstone specimen; showing impressions of feather, grooved plant-stems, and leaf of *Eucalyptus*, of the type of *E. amygdalina*, Labill. $\times \frac{4}{3}$.

PLATE V.

Fig. 3.—Feather impression more highly magnified; showing the connected structure of the vane. $\times$ 23.

4.—Piece of ironstone from the same bed as that with the feather impression; filled with leaf-impressions of a *Banksia* allied to *B. marginata*, Cavan., but probably a new species. Nat. size.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910].

Art. VI.—*Association of Alga and Fungus in Salmon Disease.*

By A. D. HARDY, F.L.S.

[Read 12th May, 1910].

In a short paper communicated to the Royal Microscopical Society, in 1907, by Dr. Hebb, I drew attention to the growth of an Alga—*Myxonema tenue* (Ag) Rabenh.—on *Carassius auratus*, found in a garden fish-pond in Melbourne.[1] Incidentally the occurrence of a fungus and a number of unicellular algae was noted. This report was responded to by Kumagasu Minakata, who described an algal growth on small fry of *Haplochilus latipes*, Schley, in a shallow bog pool of the Asso Marsh, Tanabe, Japan, and the Alga, identified in England by George Massee, proved to be the same species as that recorded by me in the foregoing case, while with it were found fragments of a diatom of the genus *Gomphonema* and a damaged individual of *Euastrum* sp. Neither Minakata nor Massee mentioned the presence of a fungus.[2]

I purpose giving a further illustration of what is, at least sometimes, an epipiscal alga, and, as the occurrence affected a large number (about 10 per cent.) of fish in the Studley Park ponds at Kew, Melbourne, the matter is raised to one of economic importance, and it may be desirable to describe the circumstances under which the trouble arose. In an appendix I offer for record the names of a number of Algae, either new for Victoria or interesting in this connection.

The new fish ponds in Kew were, less than a year ago, stocked from the ponds of the Zoological and Acclimatization Society's supply at Royal Park, where the fry had been hatched from ova imported from New Zealand, under the direction of D. Le Souëf. There is no reason for supposing that the ova

1 Jour. R.M.S., 1907, pp. 279-281.

2 "Fish Infested with Alga." Nature, Nov. 26, 1908.

may have been unhealthy, as the fry raised in the Zoological Gardens have not suffered from disease, though a few died, thinks Mr. Le Souëf, from overcrowding. In the Studley Park ponds now under notice, brown, rainbow and Lochleven trout are being reared. These are respectively *Salmo fario*, *S. irideus* and *S. levenensis.*

The ponds comprise six excavations measuring about 14 metres long x 5 m. broad; depth of water about 1.5 m. Each receives its own supply, and has a separate outlet of water. The supply is from the Yarra Yarra River, whence it is pumped up to a circular masonry reservoir in Studley Park. From the reservoir, which is close to the ponds, the water is conveyed by underground pipes to the pond's enclosure, thence by open channels in the ground, and in open wooden flumes. The pump which is used for filling the reservoir with river water is near to and below the weir at Dight's Falls, and the river, above and below, is polluted mainly by drainage from the populous suburbs on the basaltic flats on the opposite side. Though the sewerage works extension has greatly reduced the evil, there is still much that is injurious entering the river by way of Reilly-street and other drains, Merri Merri Creek, Darebin Creek, etc.

Conditions inimical to the welfare of young fry, which had hitherto rejoiced in the purity of the metropolitan domestic supply of water from the Yan Yean and Maroondah systems, were obtained during the prolonged, fierce heat of the Christmas and New Year holidays, when pumping operations partly ceased, and the water in the reservoir fell to a low level. The reservoir, used for irrigating public gardens, and for hydraulic elevators, at times contained a considerable amount of silt. In addition to the direct rays of the sun, a great amount of heat was reflected from the face of the surrounding stonework. The pipes from the reservoir were not deeply buried, and the hard ground was fairly warm during the hot weather. Thus the temperature of water in the ponds rapidly rose until a maximum of 77 degrees Fahr. was reached during an air temperature of about 100 degrees in the shade.

The first sign of trouble was the appearance, near the surface, of rainbow fry of sluggish habit, and these became gradually

more enfeebled until death ensued. Brown and Lochleven fry were also affected, but not to the same extent. On many of the fish there appeared tufts of vegetable growth similar to those noted by myself in Victoria, and by Minakata in Japan, the branched filaments of *Myxonema* being about 1 cm. long and attached to almost any part of the body, but mostly to back and sides. The fungus previously referred to was present, and I am satisfied that it is at least a member of the Saprolegniaceae, if not a species of *Saprolegnia.* Amongst the filaments of these composite tufts there were other algae, both multicellular and single-celled plants, some of the latter being motile.

While many of the weak and dying fish bore no conspicuous growth, and showed on closer examination no fungus mycelium, they were still in a diseased condition, disorganisation of the mouth parts, gills, fins and other portions of the body being easily seen, the scales having been lost from the affected areas.

Sometimes the *Saprolegnia* appeared alone, but usually, if not always, at spots where ulcerations were in evidence. I was unable to find any attached *Myxonema* apart from the fungus. It is possible that in the case quoted by Harz[1], not necessarily an enzyme, but probably a bacillus prepared the way for the fungus mycelium. On the other hand, Professor Huxley[2] insisted that this view of *Saprolegnia*, which marked it as a Saprophyte, was incorrect, and gave an account of experiments by which he was able to demonstrate the gradual encroachment of the mycelium threads, from an infected part, on sound tissue of the epidermis, which they destroyed in their progress. In view of the absence of visible fungus under ordinary microscopic examination in present case, I put forward the suggestion that a bacillus such as *B. salmonis pestis*[3] or *B. piscicidus bipolaris*[4] prepares the tissue for the *Saprolegnia*, which is then a Saprophyte, but that it may in the absence of such a bacillus adapt itself to other conditions, and then as a true parasite dissolve the tissues for itself by means of an enzyme.

1 Jour. Roy. Micr. Soc., 1907, p. 201.
2 Report, Fisheries Exhibition Literature, vol. vi., 1882.
3 Rep. British Association, 1902.
4 Proc. Linn. Soc. N.S. Wales, vol. xxv., 1900, pp. 122-130.

Some tadpoles succumbed to the disease, and these had the same disorganised mouth parts, etc., but no visible *Saprolegnia* or Alga, and therefore, keeping in mind J. Hume Patterson's statement[1] that *B. salmonis pestis* is not pathogenic to frogs, it seems probable that *B. piscicidus bipolaris*, Greig, would be found on bacteriological investigation.

The presence of *Myxonema tenue* appears to depend on the preceding growth of the fungus, in the mycelium of which zoospores of the former may be enmeshed. In the Yarra River, above Dight's Falls, this species occurs as long streamers in the current, attached to willow, twigs, etc. In the wooden flumes of the Kew fish-ponds it attained in January a length of 22 cm., and in the ponds there was a sickly growth, the poor development being evident both in reduction of size of the plants and richness of colour of chloroplasts, etc. The plants on the fish, though very small, were vigorous and rich in colour, while some of the branchlets were actively producing zoospores at time of collection. The suggestion made in my previous paper that this stream-loving plant adapts itself to comparatively stagnant water by securing a foothold on a motile substratum, seems to hold good.

The Fisheries Branch of the Ports and Harbours Department lost no time in constructing sunshades, and by thus lowering the temperature and by cleansing the reservoir, which will probably be kept at high level, has reduced the trouble in the course of a few months almost to the vanishing point.

One of Huxley's determinations, in 1882, was that the facts obtained in his investigations were not favourable to the supposition that either pollution or overcrowding had much to do with the matter, and again, that we could not make progress until the relationship between the sporadic and epidemic phases of the disease, as affecting salmon, became known. The mention of salmon disease in the Fraser River, British Columbia, and in the Castries River, Siberia, does not, for climatic reasons, affect the present case. I have endeavoured to show that, given pollution and high temperature, there is great danger, and that the trouble has been almost removed by reducing these to normal conditions.

1 Loc. cit.

APPENDIX.

List of Algae.

[* New Record for Victoria.]

1 - - From the Yarra River at Pumping Station.
2 - - From Zoological Gardens Fish Ponds. (Water from the Yan Yean and Maroondah Systems).
3 - - From the earth gutters of the fish ponds at Kew.
4 - - From the wooden flumes at the fish ponds at Kew.
5 - - Removed from the fish.
6 - - In some ferruginously-coloured spring water about 2 cm. deep, among grass, bearing an iridescent scum ; fish ponds, Kew.

Date—From January to May, 1910, excepting 1 and 5 noted for January only.

Chlorophyceae.

1, 3 - Oedogonium sp.
3, 4, 5 Myxonema tenue (Ag.), Rabenh.
3 - - Mougeotia sp.
3 - - Zygnema sp.
2 - - Closterium Ehrenbergii, Menegh.
*2 - - Closterium moniliferum (Bory), Ehrenb.
3 · Closterium Dianae, Ehrenb.
6 - - Closterium striolatum, Ehrenb.
4 - - Closterum sp.
2, 3 - Pleurotaenium coronatum (Breb.), Rabenh.
3 - - Micrasterias Mahabuleshwarensis, Hobs., forma.
*3 - - Euastrum Turnerii, West.
*5 - - Penium libellula (Focke), Nordst.
5 - - Netrium digitus (Ehr.), Itzigs and Roths.
5 - - Desmidium Baileyi (Ralfs), De Bary, forma.
2 - - Cosmarium Hardyi, G. S. West.
3 - - Cosmarium reniforme, Ralfs (?).
3 - - Cosmarium sp.

2 - - Pediastrum duplex, Meyen, var. reticulatum, Lagerh.
3 - Kirchneriella lunaris (Kirch.), Möb.
3 - - Ankistrodesmus falcatus, var. acicularis (A. Br.), G. S. West.
3 - - Scenedesmus quadricauda (Turp.), Bréb.
*1 - - Characium Pringsheimii, A. Br.
3 - - Sphaerocystis Schroeteri, Chod.

Bacillarieae.

3, 5 - Surirella robusta, Ehrenb.
*6 - - Eunotia pectinalis (Kütz), Rabenh.
3 - - Cocconema lanceolatum, Ehrenb.
*3 - - Synedra pulchella, Kütz.
3 - - Navicula sp.
5 - - Gyrosigma elongatum, W. Sm.

Myxophyceae.

3 - - Oscillatoria tenuis, Ag.
*3 - - Oscillatoria princeps, Vauch.
3 - - Phormidium tenue (Menegh.), Gom.

[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. I., 1910.

ART. VII.—*A Study of the Guttural Pouches of Horse.*

BY WALTER STAPLEY, M.D., M.R.C.V.S.

(Lecturer on Veterinary Anatomy and Surgery, Melbourne University).

[Read 26th May, 1910.]

A knowledge of comparative anatomy is apt to induce the belief that many of the variations of structure existing in different species of animals is due to some form of force operating on animal tissues. An excellent example of force dominating shape is displayed in the thorax of the horse. The weight of the horse is largely carried on the sides of the ribs, from which results a lateral narrowing of the thorax and a driving backward toward the loin, of the lung; consequently it becomes necessary for the horse to carry eighteen pairs of ribs, so that the thoracic content may be accommodated. Man's upright position has removed lateral, restricting forces from the sides of his chest; the lightness of lung tissue, unrestrained by such pressure, has caused the human lung to encroach on the neck. It is noteworthy that with ascent of the lung in the neck only twelve pairs of ribs are found, and the last or lower rib usually showing atrophic changes.

Cervical ribs are occasionally found in men and in women; they are, however, reported to be three times as common in women as in men. Whether they exist in aboriginals I do not know. The fact that the costal breathing of cultured women is said not to occur in native races leads me to think that in all probability cervical ribs are commonly found associated with atrophy of the upper limb. Surgeons have removed these neck ribs for the relief of pain. This pain is regarded to arise from stretching of the brachial plexus and the subclavian artery; it is not improbable that pain may occur during the development of these structures from an irritated pleura. From this irritated pleura arises the demand for a rib to protect the unprotected lung, and the pain arising from the same source

splints the area whilst the rib accustoms the structures, into which it is thrust, to the annoyance of the invasion.

I have prefaced my remarks on the guttural pouches of horses by this reference to force operating on the chest because it sheds some sidelight on the more hidden force effects calling into existence the hernial modifications of the auditory tube of the horse. Between the lateral and median fibro-cartilaginous laminae of the auditory tube the mucous membrane of the tube finds its exit, in sac form, into the retropharynx. Such an escape of the mucous implies an atrophy of the membranous lamina of the auditory tube. The cause of this atrophy cannot at once be seen by dissection. Searching these tissues to find the cause of this obliteration of the membranous lamina we are struck by two remarkable features in and about the throat of the horse. First the narrowness is almost as striking as the great depth of the inter mandibular space; secondly, the stylo-hyoid bone (epihyal) reaches its highest development in the horse. Upon these two facts largely depends the development of the guttural pouches. The mucous membrane of the tube has probably been dragged out of the tube by adhesion of the stylo hyoid bone with the membranous lamina and through it adhesion to the mucosa and stylo-hyoid has occurred. The development of depth of the mandible caused a descent of the larynx, with which organ were carried down the stylo-hyoid bones. The mucous folds once in the retropharynx were spread to their present confines by flexion and extension of the atlo-occipital joint, etc., through adhesion of the submucosa with the surrounding structures.

Atmospheric pressure has not produced these mucous sacs. They are to be found in the foetal foal; they are delicate sacs even in an old adult. Had they been submitted to pressure during life they should show considerable thickening. The entrance to these sacs is of sufficient size to prohibit pressure greater than atmospheric within these sacs.

The narrow and deep space through which passes the laryngo-pharynx is roofed by the base of the skull; walled by the unyielding branches of the mandible and the modified digastric muscle filling in the space between the wing of the atlas and the cervical border of the lower jaw; floored by the larynx

held firmly in the fairway of inspiration so that descent of the larynx is inhibited by the stylo-hyoid bones. Thus there is no provision outside the deep tunnel through which pass the larynx and pharynx for expansion of the pharynx during swallowing, etc. This tunnel-space runs into a dome extension in the roof. Down from the auditory tube into the dome of the retropharynx these loose folds of pouches extend themselves into a space, which, to borrow an expressive surgical term, may be termed dead space—a space formed by the developed depth of the jaw. In this space, enveloped by the mucous folds and encased by the submucosa, the superior ganglion of the sympathetic, the vagus, the hypoglossal, the glosso-pharyngeal, the spinal-accessory, the mandibular branch of the fifth nerves and the internal and external carotid arteries are found. These structures would, in this position, be damaged against such bodies as the lip of the articular surface of the atlas and the stylo-hyoid bone were it not that these folds endow the nerves and vessels with the power of passive movement during either co-ordinated or erratic muscular action. So freely do these nerves move in the exquisitely delicate submucosa that some difficulty is met in dissecting the pouches owing to the elusiveness of these structures to the forceps. A very important function of these pouches is the protection of these basal structures from injury. Without the pouches filling the dead space at the base of the skull (the retropharyngeal area) the grace of movement shown in the head and neck of the horse would be lost. They allow of free extension and flexion of the head, by the looseness of the folds with their delicate submucosa adapting themselves and their contained nerves to every movement so beautifully that nerve pressures or nerve pulls do not arise.

The air contained within these sacs probably plays some minor part in lessening the friction of movement by allowing the mucous surfaces to glide over one another with as little friction as occurs between serous surfaces. The guttural pouches represent tissues modified by force operating through the demands of speed and of food having developed depth and narrowness at the expense of breadth.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910.]

Art. VIII.—*Note on a Haemogregarine in the Blood of Varanus varius.*

By J. A. GILRUTH, D.V.Sc., M.R.C.V.S., F.R.S.E.

(Professor of Veterinary Pathology in the University of Melbourne)

(With Plate VI.).

[Read 26th May, 1910.]

Protozoa have been described as occurring in the blood of nearly all animals, generally associated with a diseased condition of the host (as Malaria and Sleeping Sickness in man, and Tick Fever in cattle), but not necessarily so, for the common rat is often found to harbour a trypanosome which seldom, if ever, produces any deleterious effects.

In many members of the Reptilia, especially the snakes, a falciform protozoan parasite has been discovered affecting the red cells of the blood. These parasites, in whatever species of cold-blooded vertebrate, are found to bear so close a resemblance to each other in general characteristics that, although by some considered to belong to one or other of three genera (Lankesterella, Karyolysus, and Haemogregarina), they are now usually placed in the one genus Haemogregarina of the family Haemogregarinidae of the group Sporozoa.

In Australia the presence of the genus Haemogregarina has been recorded in the blood of the Diamond Snake (*Python spilotes* Lacep), the Native Cat (*Dasyurus viverrinus* Shaw), in a Marsupial Squirrel (*Petaurus sciurus* Shaw), and in the Northern Carpet Snake (*Python amythestinus* Shaw), amongst native fauna, and also in the common rat (*Mus decumanus*) both in Sydney and Western Australia.[1] So far as I can find Haemogregarines have not been described in Australian lizards, though they have been elsewhere observed in species of Varanus, including one (*H. borreli*) from *Varanus griseus* described by

1 See Pro. Linn. Soc. N.S.W., 1909, p. 400 et seq. On some "Haemogregarines from Australian reptiles," by T. Harvey Johnston.

Nicolle and Comte[1] and one (*H. Varani*) from *V. niloticus* by Laveran.[2]

Recently while on a visit to the northern part of this State I had an opportunity of making post-mortem examinations on two "Goannas" (*Varanus varius*) immediately after they were shot, and some smears were made of the blood of each for subsequent examination. In the smears of one—that of a very young specimen—no parasites could be detected. But in those from the other—an animal in very fat condition, measuring about two feet from tip to tip, so not full grown—a number of red blood corpuscles were found to contain a parasite having all the characters of a Haemogregarine.

The blood smears before examination had been fixed in alcohol, and stained by Giemsa's double stain, and the following are the characters observed:—

The parasites are not numerous, in one slide only half-a-dozen intra-corpuscular bodies being detected. Some of the affected erythrocytes are distinctly larger than normal, though usually there is not any difference in size. The size of the affected red corpuscles varies from 14-17 microns long and from 8-11 microns wide, while the size of the unaffected ones rarely exceeds 14 microns long and 8 microns wide. The cell nucleus is frequently enlarged and generally eccentric, often lying close to the edge of the cell. The parasites themselves vary in size from slightly in excess of the length of the nucleus to a length exceeding that of the blood cell, when they may be seen distinctly curved inwards at either extremity. As a rule a concave border is presented towards the cell nucleus, but in one or two instances the convex border may be seen so disposed. The "capsule" is generally distinct, though in some cases indefinite. The nucleus of the parasite is almost invariably situated in the third nearest the broader, generally considered anterior, extremity. It sometimes appears as a kind of band, and in the majority of cases is sharply defined, but in one or two instances appears more or less diffuse. The cytoplasm is finely granular but often stains irregularly. The blood cell does not appear to

1 C. R. Soc. Biol., vol. lxi.

2 C. R. Soc. Biol., vol. lix.

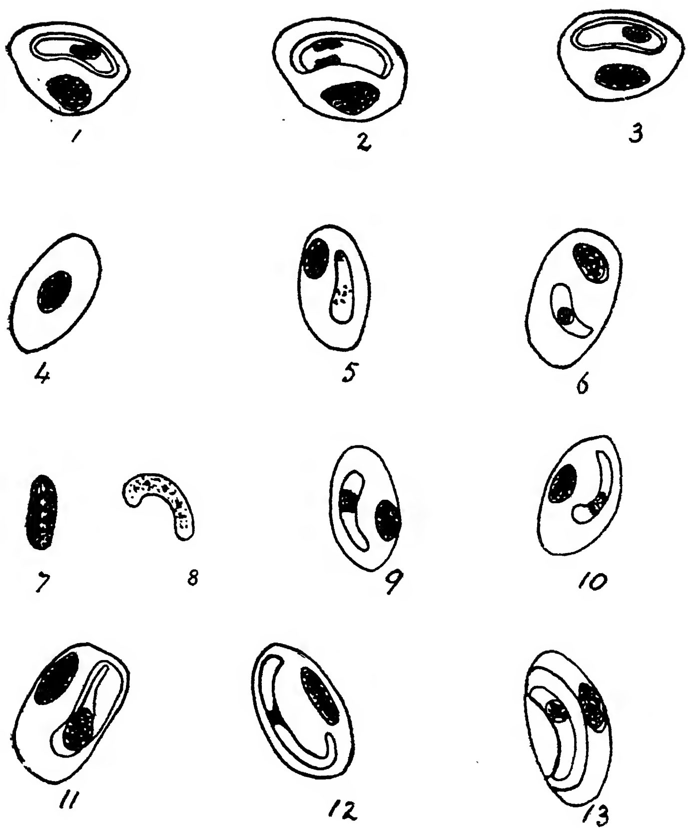
be affected in any way beyond the increase in the size of the nucleus and the occasionally observed increased size of the cell.

In addition to the intra-corpuscular parasitic bodies a large number of free bodies, broader and shorter than the gregarines (8.4 to 9.8 microns long and 4.5 to 5.6 microns wide) may be seen in the smears. The great majority are slightly ovoid, but some are somewhat curved. Although staining fairly uniformly with the basic blue stain, a number show a double irregular rod-like body centrally situated, lying longitudinally. Similar bodies are not present in the smears from the other Varanus, so while it is possible these may be extra-corpuscular forms of the gregarine, at present one cannot be definite as to their nature.

As the literature referring to Haemogregarines in other Varanidae is at present inaccessible to me, I refrain from attaching any specific name to the parasite now recorded and described.

EXPLANATION OF PLATE VI.

1, 2, 3, 11, 13 show definite capsules.
2, showing apparently divided nucleus.
4, unaffected corpuscle.
7 and 8, extra-corpuscular bodies.
10, showing "banded" nucleus.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[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910.]

Art. IX.—*On a New Species of Cellepora from the South Australian Coast.*

By C. M. MAPLESTONE.

(With Plates VII.-IX.).

[Read 9th June, 1910.]

Some seven years ago Dr. Verco of Adelaide, S.A., sent to the late Mr. J. Dennant some Corals and Polyzoa which he had dredged in South Australian waters. The Polyzoa were submitted to me for examination, and among them I found four new species, three of which belonged to Selenaria, and as I was then dealing with some fossil Selenariidae, and as these recent forms enabled me to correct some errors that had arisen with regard to the names of the species, I included a description of them in a paper treating of the Australian Selenariidae generally;* but being busily engaged with the fossils I did not then describe a very interesting massive form which was new. Having at the time returned the specimens to Dr. Verco, I lately asked him to kindly send me a typical specimen for description and presentation to our Museum, and he most generously sent me a fine series of specimens, and stated that I was quite welcome to present them to our National Museum, which I have done.

This new species is

Cellepora verticalis, n. sp. (Pls. VII.-IX.).

The zoaria are flabellate and proliferous, being composed of vertical laminae, of which there are at first generally three (sometimes four), in an upright position connected at their inner edges, or rather extending from a vertical central line laterally. Afterwards other laminae are formed, generally at obtuse angles, one after another, until the zoaria are extremely

1 Proc. Roy. Soc. Victoria (n.s.), pt. ii., p. 20, et seq.

complicated in structure. The laminae first formed consist of two single layers of zooecia, back to back, but subsequently they are overgrown with other layers of zooecia, until the laminae become thick and solid. All the laminae are perpendicular to the base of the zoarium, and this disposition of them is a constant feature, distinguishing the species from all other flabellate massive forms.

Zooecia elongate, oval; surface granulated, with occasionally a few pores, and with a few larger granulations or nodules round the margin; quite distinct and ventricose in those recently formed, but in the older ones the front wall is more highly calcified and the whole surface is raised, so that they appear quite immersed and only partially defined by a few marginal nodules, and the thyrostomes are in a depressed area. Thyrostomes subtriangular, distal angle rounded, proximal margin slightly curved. Ooecia globose, surface granulated; in the centre of the front wall, above the aperture, is a large, long, upright, elliptical area (sometimes slightly irregular in shape), with a membranous covering; ooecial opening and operculum subtriangular. Locality, Spencer Gulf (the largest specimen only), and Backstairs Passage, South Australia.

As above stated, the zoaria are composed of vertical laminae; the primary ones are generally three in number, and soon branch off at various obtuse angles to one another; the laminae are flat or nearly so, and all, even the smallest, are perpendicular to the base. In the simplest forms the laminae are few in number. One specimen has only three, joined vertically in the centre at an angle of about 120 degrees, it has developed no additional laminae, but the zooecia have grown, layer upon layer, until they are very thick. Dr. Hall has kindly photographed two of the specimens to illustrate this paper. The largest one (Pl. VII.) is 9 inches long, 8 inches wide, and 7 inches high, very solid and stony, some of the laminae being nearly half an inch thick, and the base is two inches in diameter. In the other specimen photographed (Pl. VIII.), the laminae are very numerous; there are, counting great and small, no less than 40 distinct laminae on it, most of which are composed of only two layers of zooecia; the photograph is taken looking down upon it, so as to show more clearly the disposition of the laminae.

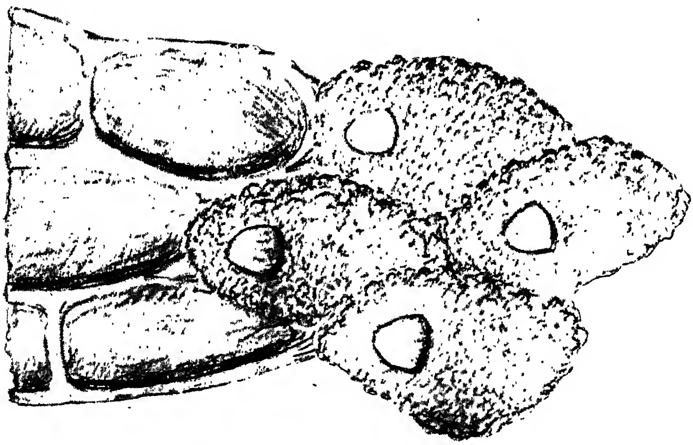


Fig I

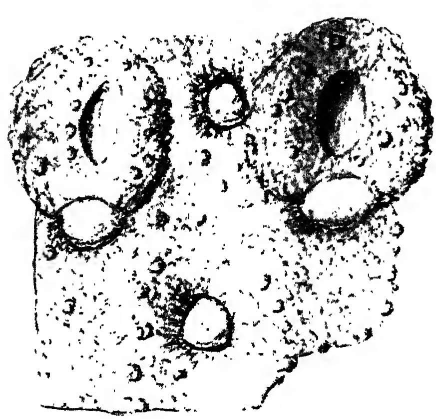


Fig. 2.

The original laminae are formed by the growth of two single layers of zooecia, back to back; these eventually being in most instances overgrown with fresh layers of zooecia until, as in the largest specimen, the thickness is very great. In some of the specimens a new layer of zooecia can be seen extending itself over the surface of the older zooecia, and the front walls of these older zooecia have become highly calcified, so as to cause the zooecia to appear to be immersed in the substance of the zoarium and to be almost indistinguishable from one another. In the new layers the zooecia are quite distinct; Plate IX. Fig 1 shows some zooecia on the growing edge.

One of the specimens has died of old age, or disease, for the various laminae, which are very thick, have become split down their centres, the bases of the primary layers of zooecia having separated from one another, and the zoarium is in separate segments, which can be fitted together to show the original form.

The ooecia (Pl. IX. Fig. 2) are very remarkable, owing to the presence in the front wall of an upright, elongated, elliptical area, with a membranous or chitinous covering, which does not appear to be of the nature of an operculum, as there is no trace of any hinge; it has come away slightly at the edges in some instances, but that is probably owing to shrinkage in drying. This structure, together with the peculiar zoarial form, is probably sufficient to warrant a new genus being established for its reception. However, at present I tentatively place it in Cellepora.

EXPLANATION OF PLATES VII.-IX.

Plate VII.

Cellepora verticalis (massive zoarium). ½ nat. size.

Plate VIII.

Cellepora verticalis (multilaminate zoarium). ½ nat size.

Plate IX.

Fig. 1.—Cellepora verticalis (zooecia at growing edge). × 48.
„ 2.—Cellepora verticalis (ooecia and older zooecia). × 48.

[PROC. ROY. SOC, VICTORIA 23 (N.S.), PT. I., 1910.]

ART. X.—*Observations on Parmularia obliqua and a Fossil Species.*

BY C. M. MAPLESTONE.

(With Plate X.)

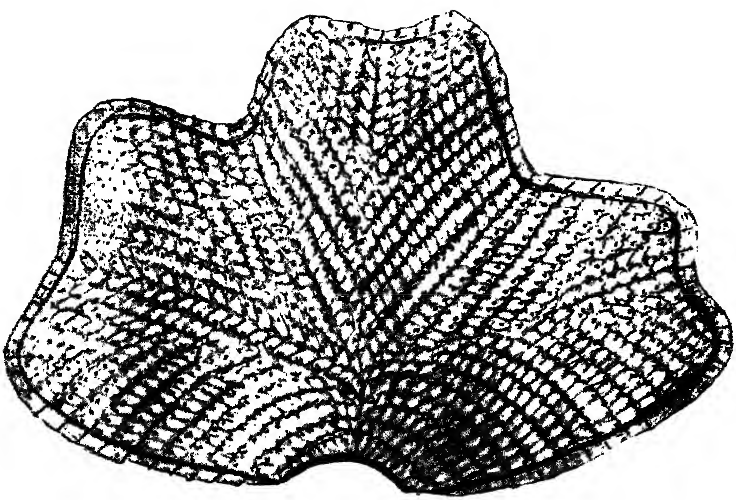
[Read 9th June, 1910.]

Parmularia obliqua, McG. (Pl. X.)

Dr. Verco also sent me some specimens of Parmularia obliqua, a species which I had not before seen. This species is described by Dr. MacGillivray under the name of Eschara obliqua in Prof. McCoy's Prodomus of the Zoology of Victoria, Decade V., page 39, plate 48, fig. 1, from the only specimen he had seen, collected at Schnapper Point, which was imperfect. Kirchenpauer also described the same form under the name of Eschara reniformis in the Catalogue of the Godeffroy Museum.

The specimens were dredged in Backstairs Passage and Gulf St. Vincent, S.A., at from 14 to 24 fathoms. They include one adult form, which is kidney-shaped, 25 mm. wide and 17 mm. high; it is composed of two layers of zooecia, back to back, and bears numerous ooecia. The other specimens are younger forms, and have not developed the kidney-shape of the adult nor ooecia; they are either fan-shaped, with obtusely crenated edges, or are palmate; in them the zooecia are arranged in regular rows, and in the palmate form illustrated is shown such a symmetrical and beautiful arrangement of the zooecia that I consider it worthy of illustration.

This species is particularly noticeable on account of its growth and habit; it does not, like most other calcareous polyzoa, grow upon the surface of rocks, algae, shells, etc., but is furnished with a long flexible stem or filament some 6 or 7 cm. long and 2 mm, thick, upon the summit of which the zoarium is attached. The point of attachment is at the curved indentation in the centre of the lower margin of the zoarium. The filament is, Dr. Verco informs me, in the living



state succulent, translucent and of a pale flesh colour, or very light terra cotta tint.

The course of the development of the stem and the zoarium presents a biological puzzle. As a rule the development of polyzoa commences with a swimming larva, which ultimately settles down and becomes attached to some foreign substance, and forms a primary zooecium (ancestrula), around or upon which other zooecia grow. It is doubtful if this species could begin its existence in this way, because if the primary zooecium were firmly attached to any foreign substance the stem could not grow. An examination of the specimens does not disclose any signs of a single primary zooecium; instead of which there is a row of zooecia (16 in the specimen figured), somewhat different in form from the succeeding ones, from the bases of which there are numerous short filamentary processes which project over the cavity that in the living state was occupied by the stem, and which apparently were embedded in it and by them the zoarium was attached to the stem.

In connection with this species I would wish to state that, owing to my not having then seen a specimen of it, I described in Part VII. of my "Further Descriptions of Victorian Tertiary Polyzoa" (P.R.S., V. Vol. XIV. (New Series), Pt. II. p. 68, pl. VIII. fig. 10), under the name of Schizoporella flabellata, a form which belongs to the genus Parmularia, and that consequently its name must be altered to "Parmularia flabellata"; it differs from P. obliqua in that the zooecia are perpendicularly arranged, not obliquely, and the form of the zoarium is elongated and elliptical, not broad and fan or kidney-shaped.

DESCRIPTION OF PLATE X.

Parmularia obliqua. × 8.

[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. I., 1910.]

ART. XI.—*Notes on the Geology of the Country about Anglesea.*

BY T. S. HALL, M.A., D.Sc.,

University of Melbourne.

(With Plate XI.)

[Read 9th June, 1910.]

The hamlet of Anglesea lies near the mouth of the so-called "river" of the same name, eight miles in a direct line south-west of the mouth of Spring Creek, the typical locality of the Jan Jukian beds of the tertiary series. The old name of the Anglesea River was Swampy or Salt Creek. Six miles further to the south-west, Airey's Creek enters the sea at Airey's Inlet, and from here eight miles away across Loutit Bay, the houses of Lorne may be seen nestling on the wooded flanks of the Otway Hills.

Previous references to the geology of the district are scanty. Daintree in 1863, after briefly discussing the section displayed at Bird Rock, mentions, half-way between Point Addis and Jan Juc, the presence of cliffs of sands, black with carbonaceous matter. In them, he says, "a remarkable instance of the preservation of fossils occurs. All the large imbedded shells are entirely decomposed, and where their casts remain they are imperfectly rendered in iron pyrites, whilst minute foraminiferae, abundant in the rocks, are preserved intact." He does not say whereabouts in his series he would place these beds.

Krausé, in 1874, after a very hurried survey, roughly mapped the Cape Otway District, and several notes are given on the coast between Spring Creek and Point Castries, where the tertiaries thin out on the Jurassic strata. A few corrections in detail are required. Thus the dips given are usually the apparent, and not the true ones. A creek is shown entering the sea on the east side of Point Addis, and another about a mile east of Salt Creek (Anglesea River), though neither of these

exist. Still, the map is useful as far as it goes, and, considering the amount of ground Krausé had to cover in the time allotted, the result as a whole is one we must thank him for.

Mr. J. F. Mulder, in 1893, gave a list of a dozen species of fossils from the Airey's Inlet limestone, but added nothing further to our knowledge.

The coast between Spring Creek and Rocky Point, a distance of about two and a-half miles, has been briefly described by Professor Tate and Mr. Dennant in 1893 and 1895. Mr. Pritchard and I also discussed the relationships of the same beds in 1896.

Mr. A. G. Campbell, in a short sketch of the botany and geology of the coast between Point Addis and Anglesea, mentions the "tall cliffs of mud-like material," and refers to "somewhat similar beds beyond Anglesea, containing fragments of volcanic scoria to the size of a football, and an occasional waterworn basalt pebble," and thinks that "these clayey cliffs mark the proximity of once-extensive lava-fields, long since disappeared."

The fossiliferous yellow limestone of Rocky Point continues along the coast to the south-west for about the third of a mile, and on rounding a small point it is seen to overlie purple and black, sandy clays, and to dip E. 10 degrees S. at 5 degrees or 6 degrees. The inward sweep of the bay has cut out the limestones from the cliff face, and inland they have been removed by denudation, their thickness being small. A couple of miles further on Point Addis forms a low but prominent headland, which is capped by the same limestone to a thickness, according to Krausé, of 60 feet. Between Point Addis and the previously mentioned point three reefs occur in the sea, which are in a straight line, and evidently are due to the induration of bottom beds of the limestone.

The Point Addis limestones are yellowish in colour, and in places very concretionary and ragged. Quartz sand of a roughened, granitic character is of frequent occurrence, and at times forms thin bands. Indurated bands and patches are common, and the rock is in places quite crystalline, a character previously referred to by Mr. Pritchard and myself, and believed by us to be due to the impervious sandy clays on which the calcareous series rests. The variety of fossils is small, but

the locality is remarkable for the extreme abundance of *Cassidulus australiae* (Duncan), while *Magasella compta* (T. Woods) is almost as plentiful.

The purple and black clays, which are seen in cliff section to underlie the limestones, are weathered to a lighter hue in their more superficial parts, and it is chiefly to this weathering that the various beds measured by Krausé, and recorded in a note on his map, are due. This section is the one previously mentioned by Daintree as containing pyritic casts of mollusca and unaltered foraminifera. I have never carefully searched for fossils, and have seen none in the beds. Daintree evidently regards the black beds as the equivalent of the marine series of Bird Rock, though he is not clear on the point. On rounding Point Addis, and traversing half a mile of sandy beach, a small point is met with, consisting of ferruginous sands, and quartz conglomerates. This is known as the Black Rocks. From here to the mouth of the Anglesea River the coast is marked by vertical cliffs of black sandy clays. These beds are similar to those on the other side of Point Addis just referred to, and are of a very striking character. Beyond the mouth of the river, after passing a small strip of sand dunes which mark the extent of oscillation of the mouth, we encounter an outcrop of ferruginous conglomerates and sands interbedded in the black sandy clays, but of only small lateral extent. They form a small point on the beach, and are very similar to those at the Black Rocks. The sands and clays form cliffs of gradually lessening height from here to the shoreward end of Point Roadknight, which is formed entirely of dune limestone.

At the mouth of the Anglesea River the older tertiary forms the east bank, and a hard outcrop occurs on the beach. It also forms a reef bare at half tide a short distance off shore, while another reef of perhaps a similar character, the "Hereford Reef," from the name of a ship wrecked on it, occurs a mile to the east. Banked against the older rock at the river mouth are a few small patches of indurated sand forming a small raised beach. In this I found several paired valves of *Chione scalarina* in the living position, and some large examples of *Lampania australis*. Krausé, on his map, marks "sandy limestone" here, and probably refers to this small outcrop.

The black, sandy clays between here and Point Addis are weathered to a fawn colour in their upper part, and the change to purplish black is rather sudden. As the weathering follows the contour of the ground, the beds appear to form a gently swelling anticline, with the lower beds showing to a thickness of about 40 or 50 feet in the middle of the section. An examination, however, shows that the appearance is deceptive, and is merely a colour effect.

The chief peculiarity in the black series is its jointing. In one place not far from Anglesea rectangular prisms, with a four or five inch face, are developed, the joint faces being vertical. In other places, and far more commonly, great sheets flake off the vertical cliffs and fall or hang in threatening positions nearly a hundred feet above the beach. Still nearer to Point Addis, for over half a mile, the cliffs, here about 150 feet in height, form a confused mass of tumbled heaps. The dip of the undisturbed strata is small, but holds steadily to seaward along the straight coastline, and great masses have apparently glided down the dip-slope and formed the landslips. The dip can be seen along the shore towards Point Roadknight, and on a small point a couple of miles west of Point Addis.

The siliceous grits which were noted in the lower part of the Addis Limestone also occur in the underlying series even down to the lowest part of the black beds. They seem to grow coarser near the top of the cliffs, and small beds of waterworn quartz-gravel occur frequently here, near where the limestone probably once lay before its removal by denudation.

In the black, unweathered beds seams and small nodules of iron pyrites are of common occurrence. The weathering of this into copiapite was noted by Daintree, while near Point Roadknight alum occurs as an incrustation which has a greenish tinge.

Remembering Daintree's record of pyritic casts from the beds near Point Addis, I searched for a long time near Anglesea for fossils in these barren beds. The occurrence of lignitic fragments, which are fairly common in places, gave me the idea that perhaps the beds were, after all, of freshwater origin, but later on this idea was dissipated by the finding of a tooth of *Odontapis contortidens* Ag., and numerous examples of fora-

minifera, as recorded by Daintree, and mentioned above. These have kindly been identified by Mr. F. Chapman. I found no pyritic casts of molluscan or other shells.

The oxidation of the pyrites has evidently given rise to the limonite, or at times haematite, which had cemented the sands and conglomerates at many exposures; for instance, the Black Rocks, near Point Addis, the similar rocks half a mile west of the river mouth, and the ironstone hill on which the Anglesea Hotel is built. Similar ironstone conglomerates occur on the river banks higher up, and at many places on the roads leading to Jan Juc and Airey's Inlet. Moreover, wells sunk at a farm a mile inland up the valley yield water so highly mineralised that it is useless for stock or for garden use, probably from dissolved sulphates.

A mile west of the mouth of the river, the face of the cliffs, which rapidly decrease in height as we approach Point Roadknight, are occupied by extensive landslips, which are well overgrown by trees at their northern end, but broken and crevassed along the sea front, and evidently have moved quite recently, as the surface is bare of vegetation. An examination of the cliff face shows that the overlying sandy strata have moved over a clay bed of a peculiar nature, which passes below sea level with a steady southerly dip. The bed of clay, which is about twelve feet thick, when traced easterly soon runs up to the top of the cliff, and cuts out at the top, the cliff being about 80 ft. high. The underlying beds are evidently the representatives of the black series further east, but are bleached to a greyish hue. Hereabouts they are protected by Point Roadknight from the rapid wearing by the sea, and there is time for weathering to act on the face, while further eastward the unsheltered cliffs are rapidly cut back.

The clay bed mentioned above is, as already stated, about twelve feet in thickness. Its ground mass is bluish grey, and scattered through it are white angular pieces of clay, rarely more than an inch in diameter. On tracing the bed to a small point, which can be passed round at about half tide, we find it has slightly altered in colour, being of a greenish grey hue, and is carved into small pinnacles and chasms by the waves. The whole mass can be cut easily by the knife, but

here and there fragments of what appear to be basaltic scoria are to be found. They are, however, quite decomposed to clay, and only the weathered face gives any clue to their nature. Search among the pebbles at the foot yielded a few fragments of dense basalt, which may or may not have been derived from this bed. The clay conglomerate contains a few quartz pebbles, and sand grains are common, while a few rock fragments occur which all seem to be derived from rocks similar to the underlying series, and of tertiary age.

The great bulk of the bed is evidently made up of fragments of a basaltic rock, and I feel convinced that it is a tuff. The thick tuff beds associated with the Airey's Inlet basalt are, it may be mentioned, only about three miles away along the coast. Mr. A. G. Campbell, who noticed the basalt fragments about here, believed that the bed was derived by denudation from a basalt flow.

If the clay bed be really a tuff, it then throws interesting light on the Spring Creek series, as well as on that of Airey's Inlet. To this I shall refer after a short description of the latter.

In walking to the westward along the coast from Point Roadknight, we see very little but sand dunes for about three miles, when we encounter cliffs of yellowish and drab tuffs. Overlying these is a series of ferruginous sands and gravels. The tuffs are splendidly shown in cliff section for a couple of miles to a thickness of from 20 to 30 feet. They vary much in the size of the component fragments, and are very much decomposed. In places basaltic fragments up to two feet in diameter are common, together with fragments of sandstone and shale of doubtful age. Near Eagle's Nest solid basalt forms the base of the cliffs, and underlies the ash beds. As a rule the basalt is black and dense, but occasionally its upper part is vesicular, and filled with amygdules of lime. It is possible that a careful examination of the dip of the tuffs may fix the site of the vent which cannot be very far away, if we may judge by the size of the included fragments. It is probable that it lies out to sea.

The upper surface of the basalt has been deeply denuded, and on this worn surface lie the Airey's Inlet Limestones. These

are yellow detrital limestones, very similar to those of Point Addis in every way. Quartz grains are plentiful, and the same fossils occur, polyzoa making up the bulk of the rock. At Split Point the surface of the underlying basalt is cut by channels, and is very bouldery, so that the limestone forms deep pockets, and in cliff section islands of limestone appear in the basalt, the connection with the overlying beds being not always shown. Some of these pockets go down twenty feet below the main mass, and in them the rock is quite unaltered and similar to the massive beds above, so that fossils may be easily picked out. Where the limestone overlies the ash beds it is generally changed to a pink crystalline rock of varying thickness.

As pointed out some years ago by Mr. Pritchard and myself, the contact of the limestone and basalt is a repetition of what is found near Maude, a feature which struck us when we visited Split Point in 1894.

The Jurassic rocks of the Otways come in on the shore line near Point Castries, about four miles further to the south-west, and between Point Castries and Airey's Inlet occurs a series of beds which are clearly of tertiary age, but whose relationships to the beds further east has been matter of doubt. They have been described in some detail by Krausé, since, close to the Jurassic, they contain small lignite seams. They are as a rule very sandy, and in places quartz gravels occur, and at Point Castries Krausé notes black clays resting on the Jurassic.

It seems almost certain that these western beds represent the black beds of Anglesea, and are of fresh water origin. As we go north-east along the coast, the influence of marine conditions is more strongly felt, and near Anglesea marine fossils, as mentioned, are sparingly found. Still further on the character of the beds beneath the yellow limestone changes; gravels and grits disappear, and at Rocky Point marine fossils of all kinds are common, the beds becoming richer as we approach Bird Rock. The limestones of Airey's Inlet (Split Point), Point Addis, and about the mouth of the Jan Juc Creek, seem to be on the same horizon, as the echinoderm fauna at any rate appears to show.

If the bed described near Point Roadknight be indeed a tuff, as I am strongly inclined to think, then it is almost certainly

a part of the Airey's Inlet tuffs, and these are, if my inferences be correct, contemporaneous with part of the Spring Creek lower beds or of Jan Jukian age, and to the same series must be referred the beds between Airey's and Point Castries.

Krausé has marked on his map, and described in his notes a division between a lower series of rocks which he calls Miocene, and an overlying series which he calls Pliocene. The "Miocene" is mapped only along the sea coast, with an extension up the valley of Spring Creek, owing to the removal of the overlying "Pliocene," but I do not know on what this subdivision rests, and am unable to see any justification for it.

Physiographically the country between Geelong and Anglesea is a coastal plain, with a mean elevation of perhaps two hundred feet. From west to east across this a broad valley, five or six miles wide, has been excavated, and subsequently partly flooded by a series of lava flows of "upper volcanic" age. This valley is drained mainly by Thompson's or Bream Creek. The lava is a tongue from the western plains, and comes down the Barwon Valley from the south of Winchelsea. The River Barwon turns abruptly north near this town, but probably its old course was along the wide, mature valley now occupied by the lava flow, which enters the sea as a broad flood between the mouths of the Barwon and Bream Creek.

As this valley is excavated in sandy beds which crop out extensively along its margin, it is evident that a considerable part of the rainfall is probably absorbed, and sinks below the basalt. This being the case, it seems almost certain that a line of bores across the lava stream would tap a supply of underground water, which would be of value in augmenting the deficient summer supply of this area. As is usually the case in basaltic country, what streams there are, are highly mineralised, and the dissolved salts flocculate the suspended clay, and so cause its precipitation, leaving the water clear, and an object of suspicion to the traveller. The old bush maxim is justified which says, of two streams choose the muddy one as being probably better water.

The coastal plain is sandy, and the soil is extremely poor, so that the timber which grows on it to the south of Jan Juc affords only second-rate firewood, and is fit for little else. As

we approach the plateau near Anglesea from the lava-floored valley, the heights are rather striking, and are dignified by the name of the Anglesea Ranges. Once on the plateau the coast road easily avoids all valleys, and runs level till the Anglesea Valley is reached. This near its mouth is about three miles wide, and is trenched to a depth of about 200 feet. Towards Airey's Inlet the elevation increases as the beds begin to rise on the flanks of the Jurassic, and the streams have greater cutting power, and are more numerous, so that broad stretches of level country are less frequent.

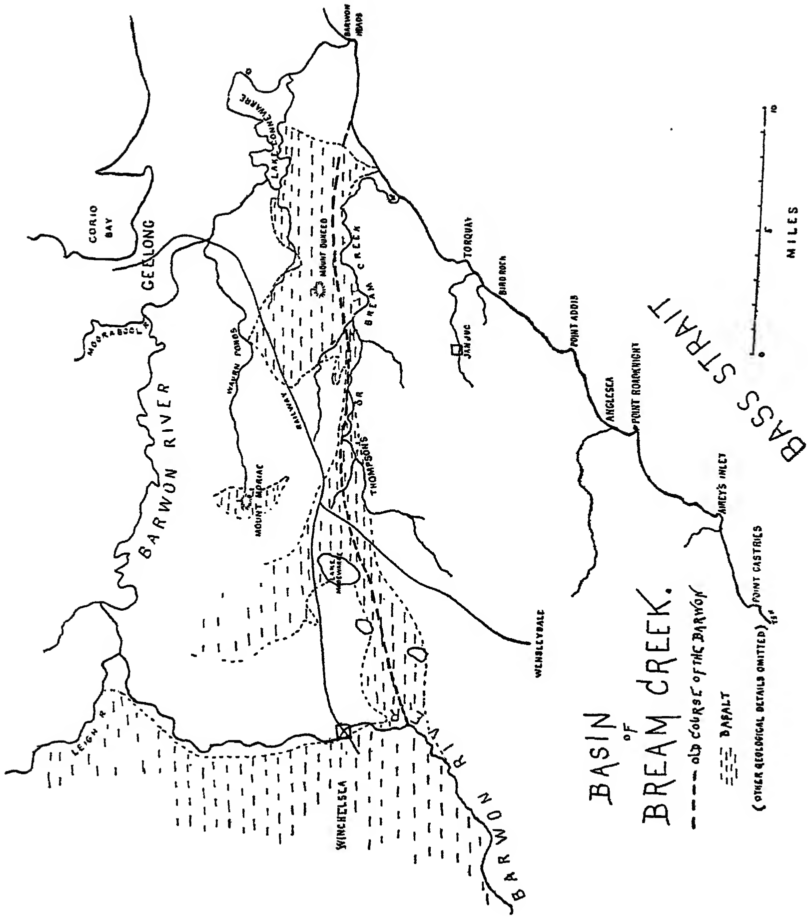
Airey's Inlet is curiously named, for there is no inlet from the sea; the small creek is usually barred completely by sand banks, but was possibly opened by floods at the time it was named.

The valley of Spring Creek is a modern one, and is steep-sided near the township of Jan Juc, where a fairly fertile soil is derived from the waste of the earthly limestones exposed.

I give a list of the fossils I have identified from my gatherings at Point Addis and Airey's Inlet (Split Point), and quote their Spring Creek record:—

	Airey's.	Addis.	Spring Creek.
Paradoxechinus novus, Laube	1	1	1
Monostychia australis, Laube	1	1	1
Scutellina patella, Tate	1	1	1
Fibularia gregata, Tate	1	—	1
Cassidulus australiae, (Duncan)	1	1	1
Eupatagus murrayensis, Duncan	1	1	1
Eupatagus rotundus, Duncan	—	1	1
Duncaniaster australis, (Duncan)	?	—	1
Pentagonaster sp.	—	1	—
Terebratulina catinuliformis, Tate	1	—	1
Magasella compta, Sow.	1	1	1
Dimya dissimilis, Tate	—	1	1
Pecten hochstetteri, Zittel	—	1	1
Spondylus gaederopoides, McCoy	—	1	1

There is thus an almost complete identity of fossil contents, and the beds are on the same horizon.


BASIN
OF
BREAM CREEK.
OLD COURSE OF THE BARWON
BASALT
(OTHER GEOLOGICAL DETAILS OMITTED)
BASS STRAIT
MILES
CORIO BAY
GEELONG
MOORABOOL R
BARWON RIVER
WAURN PONDS
MOUNT MORIAC
RAILWAY
MOUNT DUNEED
LAKE CONNEWARRE
BARWON HEADS
BREAM CREEK
THOMPSONS CR
TORQUAY
JAN JUC
BIRD ROCK
POINT ADDIS
ANGLESEA
POINT ROADKNIGHT
AIREY'S INLET
POINT CASTRIES
WENSLEYDALE
LAKE MODEWARRE
WINCHELSEA
LEIGH R
BARWON RIVER

SUMMARY.

The polyzoal limestones of Airey's Inlet, Point Addis and Spring Creek are on the same horizon. The black sandy clays of the Anglesea coast are of marine origin, and are apparently the equivalents of the rich marine beds of Spring Creek to the eastward and of the lignitic series which rests on the Jurassics to the west of Airey's Inlet. The presence of a tuff interbedded with the sandy clays of the series at Point Roadknight goes to show that the basalts and tuffs of Airey's Inlet are intercalated in beds which are the equivalents in age of the marine clays of Spring Creek. The older basalt of this district is then of typical Janjukian age.

The country between Geelong and Anglesea is a coastal plain trenched by a broad, mature valley floored by basalt. This is probably the old valley of the Barwon, which entered the sea not far from its present mouth. Near Anglesea the coastal plain is not greatly dissected.

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EXPLANATION OF PLATE XI.

Sketch Map, showing the basin of Bream Creek and neighbouring country.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910.]

Art. XII.—*Contributions to the Flora of Australia, No. 14.*[1]

BY

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(With Plates XII.-XIII.)

[Read 9th June, 1910.]

Atriplex patulum, L. var hastata, Gray. (A. hastata L.). (Chenopodiaceae).

H. B. Williamson, Foreshore, Geelong, April, 1910; Railway Reserve, N. Melbourne, J. R. Tovey and C. French, junr., April, 1910.

A. patulum has already been recorded as a naturalised alien, but not this variety, which is still recognised in the Kew Index and in Engler's Pflanzenfamilien as a distinct species, although both Gray and Bentham have shown the necessity of including it with other forms, as varieties of or subspecies of *A. patulum*.

Bupleurum rotundifolium, L. (Umbelliferae). "Hare's ear."

Lower Loddon, R. Thorn, 1882; Huntly, L. Fraser, Nov., 1875; and various Victorian localities; near Sydney (New South Wales); Dr. Woolls, Oct., 1871.

Naturalised as an alien in Victoria, but not previously recorded.

The plant has been by some identified as *B. protractum*, Hoff. and Link. If this species is valid, it is distinguished by

1 No. 13 in vol. xxi., 1910, p. 315, of the Proceedings of this Society.

the stem-leaves being much longer than they are broad instead of nearly circular as in the present specimens, with less than 5 bracts; the number of bracts in the umbels of both forms varies from 3—5, rarely more. The plant is native to the Mediterranean regions, and has hence spread to Europe, Asia, North America and Australia.

BURSARIA SPINOSA, Cav. (Pittosporeae).

Various forms of this pleomorphic species have been described as distinct species at different times, upon variations in the shape and size of the leaves, presence or absence of spines, hairs, size of the adult plant, etc. Such characteristics are, however, precisely those most liable to local adaptive modifications and least reliable as specific distinctions. A careful examination of the 200 odd specimens from all parts of Australia existing at the National Herbarium shows that 3 fairly marked varieties of this species can be recognised, but that even the most marked one (var. *incana*) is connected with the type and with the other varieties by numerous intervening forms. The forms are:—

Bursaria spinosa. Cav. The "type" form is merely what remains when the three varieties are removed. It comes from all parts of Australia, and includes at least 20 intermediate forms. It varies from a shrub to a tree 40 feet high, and is usually without spines.

Var. *incana* This form has long, narrow more or less pointed leaves up to 3 inches or more in length, with a white tomentum on the under surface. It is commonest in tropical Australia, and the pods are usually rather larger than in the other forms. In the west and south of Australia specimens are found with shorter and broader leaves, but the tomentum still present. (*B. incana*, Lindl.)

Var. *luxurians.* This has also large leaves, but they are shorter, tomentum on the under side. In other respects it is identical with the "type." It appears to be commoner in the S.E. of broader and more obtuse than in var. *incana* and have no Australia, particularly in moist valleys near the sea coast, but also extends as far North as Queensland. It may include the *B. tenuifolia* of Bailey. (Flora of Queensland, p. 72), but no

authentic specimens of that variety have been seen. The "*B. Pantoni*" of W. R. Guilfoyle (Vict. Naturalist, Vol. XVII., 1900, p. 42) is merely a form of *B. spinosa* approaching towards this variety.

Var. *microphylla.* The leaves vary in shape, but are always small, often less than half a centimetre in length. Most of the shrubby, spiny specimens come under this variety, which mainly occurs in New South Wales, Victoria and South Australia, although it also extends as far north as Queensland. A specimen from Stawell (F. M. Reader, 1904) is interesting in having the leaves with the tomentum of var. *incana* on the under sides, but being otherwise identical with var. *microphylla.*

Apparently *Bursaria spinosa* is a plant which has spread over Australia in comparatively recent times, and is in process of adaptive modification into at least three and possibly more distinct species. Since all the connecting links still exist, however, it is not possible to separate these forms into distinct species, and the decision, whether a particular specimen belongs to a variety or the type is often merely a matter of choice.

Centaurea nigra, L. (Compositae). "Knapweed."

A native of Europe, now growing wild, and sufficiently established to be considered naturalised at Sale, Gippsland, Williamson; Freeburgh, N.E. Victoria, per Department of Agriculture, February, 1910; Terang, C. B. Palmer, March, 1910.

It has suddenly appeared at several localities, probably spread with a batch of impure agricultural seed, and is not likely to die out again. Though useless the plant is not prickly or obnoxious in the same way as is the Star Thistle (*Centaurea calcitrapa.*) It is not, however, an alien to welcome.

Chenopodium rubrum, L. (Chenopodiaceae). "Red Goosefoot."

Railway Reserve, N. Melbourne, May, 1900, C. French, jnr., and J. R. Tovey.

The plant is a native of Europe and of Russian Asia except at the extreme north. It grows on roadsides, rubbish heaps, old manure tips and waste places, and is usually easily recognised by its peculiarity of turning red, first on the stems, and especially when near the sea. In Victoria it has probably been frequently mistaken for *Chenopodium murale*, which is native, and which it resembles externally. The exotic *C. urbicum* L., to which it is closely allied, does not as yet appear to have entered Victoria.

The plant is not poisonous. Its young shoots and leaves have been used as a kind of spinach, and it also has a slight value as a low grade fodder plant, especially for sheep. In cultivated land it readily becomes a troublesome weed if neglected.

Chorizema nervosa, T. Moore. (Leguminosae).

Near Cape Arid, West Australia, 1875; Maxwell, West Australia; T. Drummond, No. 23 (not of 6th Coll., possibly of 5th Coll.).

The latter specimen was placed under *Gastrolobium bidens* Meisn., by Mueller, as the type of that species in Australia on the basis of Bentham's reference to No. 23, Drummond's 6th Coll. as *Gastrolobium bidens.* Noting the discrepancy in the description a portion of the type of the true *G. bidens* was obtained from Kew, which proved to be a different plant, and the identification was corrected as above. *Chorizema nervosa* is the No. 25 of Drummond's 5th collection. The present No. 23, may be of the 5th or some other collection, but not of the 6th collection.

Ehrharta panicea, Smith. (Gramineae). (E. erecta, Lam).

Goulburn, Nov., 1904; C. Walter (probably planted as a pasture grass); Domain, South Yarra, J. W. Audas and Colonel Goldstein, March, 1910 (growing wild as a garden escape).

This S. African grass is a perennial with more or less creeping stems. It has a certain value as feed for grazing stock, but only grows well in fairly moist or protected shady localities.

In gardens and cultivated land it would be apt to become a troublesome weed.

ESCHSCHOLTZIA CALIFORNICA, Cham. (Papaveraceae).

Growing wild on the flats along the Loddon at Baringhup. Apparently a garden escape hardly naturalised as yet.

J. M. B. Connor, April, 1910.

GNAPHALIUM PURPUREUM, L. (Compositae) "Purple cud weed."

Near Dimboola, F. M. Reader, August, 1893; Korumburra, H. Crisp, December, 1902; Otway Forest, H. B. Williamson, December, 1903; Gippsland, W. Wallace, November, 1904; Toora, W. Stewart, December, 1907.

This plant has not been hitherto admitted into the census as Victorian owing to the specimens having been classed as a variety of Gnaphalium japonicum. Although they have not the woolly bracts of the original Australian type specimens they have the pappus hairs cohering in a distinct ring at the base, and tally closely with old world specimens. The woolliness of the bracts and the shape of the leaves appear to be variable features.

HALGANIA ERECTA, n. sp., Ewart and Rees,

Victoria Desert Camp, 38, September, 1891, R. Helms.

Small branching shrub about 8in. in height. Stems woody, bearing a glandular viscid scabrescence intermingled with a few rigid appressed hairs of peculiar type, and as in *H. strigosa* attached at the centre, and having two processes extending apically and basally in the same line or at a slight angle. Leaves about $\frac{1}{4}$ in. long, entire when young, usually becoming slightly 3-dentate when older, appressed, sessile, slightly narrowed at the base, margins incurved, whole leaf somewhat concave, under surface bears a number of stiff white hairs similar to those on the stems, also traces of the viscid scabrescence. Flowers stalked apparently solitary and axillary—Calyx—5 sepals, $1\frac{1}{2}$ lines long, linear accuminate bearing short hairs. Petals dark blue rather broad, narrowing to pointed apex,

longer and more accuminate than those of H. strigosa. Stamens with very short filaments, anthers about one line long, each with long straight process about twice as long as anther itself, processes free at tip, much longer than those of H. strigosa. The plant is nearest to *H. strigosa*, Schlect, but is smaller, has stouter and more numerous hairs, much smaller appressed leaves, and longer anther appendages. From *H viscosa*, Spencer Le Moore, it differs in having the strigose indumentum even more strongly developed than in *H. strigosa,* in the shorter and broader leaves, in the solitary stalked flowers and in the anther appendages.

HELIPTERUM SPLENDIDUM, Hemsley, Botanical Magazine. Tab. 7983, 1904 = H. ROSEUM, Benth. var. ALBA (Compositae).

Hemsley's type specimen is a large flowered form of this species agreeing in the anthers, styles, bracts, achenes, pappus, and leaves with the various forms of this somewhat variable species. Plants grown at the Botanical Gardens from seed obtained from Berthoud, in West Australia (who provided the material through which the plant reached Kew, and was described as a new species), reverted to the smaller flowered typical form of the variety alba. The large flowered form is possibly only developed under intensive cultivation.

KYLLINGIA BREVIFOLIA, Roth. (Cyperaceae). Det. by G. Kukenthal.

Port Jackson, R. Siegert, 1884. Probably introduced.

LINARIA VULGARIS, L. (Scrophularineae). "Common Toad Flax."

Bloomfield, Feb., 1910, J. P. McLennan.

Apparently a garden escape hardly yet sufficiently established to be considered naturalised. The plant is native to Europe and Russian Asia, but has spread with crops to various parts of the world. Hence it is likely to appear in other localities in Victoria, and to persist when once established. Its yellow clusters of flowers are rather handsome. Though without economic value it does not appear to be aggressively

injurious. It was formerly used as a diuretic and laxative purgative. No animal will eat it, and as bedding in cow-stalls it helps to keep away vermin. Milk boiled with it will kill flies, so that it is apparently somewhat poisonous.

Linaria Elatine, Mill. The Hairy Toad Flax is a naturalised alien, and is often sent in as a supposed poison plant. It has not hitherto been shown to be poisonous. Bourquelot (Journ. Pharm. et Chim., 6 ser., 30, 1909, p. 385) has, however, shown that another European common roadside weed (*Linaria striata*), generally avoided by sheep, contains a cyanogenetic glucoside which, under the action of emulsin, yields hydrocyanic acid, benzoicaldehyde, and a reducing sugar. *L. Elatine* and *L. striata*, both appear to have a similar bitter taste and hence it is possible that both may be capable of producing poisonous effects.

MELALEUCA NEGLECTA, Ewart and Wood, n. sp. (Myrtaceae).

Shrub not over 8 feet in height, stem two or three inches in diameter at the base, bark rough and corky, slightly furrowed. Leaves 2 to 3 lines in length, ovate-lanceolate, stalked, tuberculate, semi-terete, flat on top, scattered and numerous. Flowers small whitish, numerous in lateral spikes; axis grows through the inflorescence before flowering is over. Calyx tube campanulate, lobes 5 triangular nearly as long as the tube. Corolla white, petals 5 deflexed, clawed, very thin and delicate. Stamens in 5 bundles, opposite petals, 7 to 9 in each bundle. Ovary hairy on top, single style and stigma, 3-celled, ovules erect, placenta bifid.

Remarks. This plant differs from *Melaleuca pustulata* in that its bark is not smooth and papery. The flowers of *Melaleuca pustutata* are in small terminal leafy heads, and the rhachis as a rule does not grow out until flowering is over. The flowers differ in the two plants in external appearance, the calyx lobes of *M. pustulata* are longer than broad, and more pointed. The petals also differ, the petal of *M. pustulata* being longer, more ovate, and claw is shorter. The plant is of no value as timber, owing to its small height. Its non-recognition as a distinct species has been due to its being

confused with *M. pustulata.* Hitherto it is only known from Victorian localities. Attention to the possibility of this plant proving to be a new species was first drawn by Mr. St. Eloy D'Alton. Hence its popular name might be D'Alton's Melaleuca.

Habitat, near Dimboola. *Collector,* St. Eloy D'Alton. *Date,* November, 1909.

PHYSALIS VISCOSA, L. (Solanaceae). "Ground Cherry."

Railway Reserve, N. Melbourne; J. R. Tovey and C. French, jnr., March, 1909, and April, 1910.

The plant is a native of the Southern Regions of North America, where it is common, usually on light or sandy soils near the coast. It is a perennial with somewhat creeping subterranean shoots, and hence would be difficult to eradicate when once established. It has apparently been introduced with ballast, and has not yet appeared from any other locality. The berries do not appear to ripen readily in this climate. The plant is easily recognised by its short pubescence of stellate or forked hairs.

PRASOPHYLLUM INTRICATUM, C. Stuart.

New England, Timbarra (New South Wales), C. Stuart.

This Tasmanian and Victorian plant is only recorded previously from a single locality in New South Wales. (Blue Mountains, Fitzgerald's Australian Orchids). The present specimen was wrongly named P. Archeri.

PULTENAEA VILLIFERA, Sieb.

East Gippsland, November, 1896, H. B. Williamson.

This plant is given in Mueller's key as from the North West only of Victoria. In addition to the present locality it also occurs in the South and South-West (Macedon, Geelong, Portland).

SAGITTARIA SAGITTAEFOLIA, L. "Arrowhead."

A semi-aquatic plant, native of Europe and temperate Asia, growing in swamps, shallow ponds and streams. It is now

naturalised in swamps on the Goulburn River, near Nagambie. Possibly it was planted in the first instance, and has since run wild. It was formerly used as a cooling and wound healing specific, but has now no reputed medicinal value. The root contains starch like that of arrowroot, and is used as food by the Kalmucks. The leaves do not appear to be injurious, and though hardly to be classed as good fodder are apparently eaten by stock when better feed is unavailable.

C. French, jnr., 1910.

SENECIO SPATHULATUS, A. Rich. (Compositae). "Spoon-leaved Groundsel."

Mt. Singapore, Wilson's Promontory, J. A. Leach, May, 1910. New to the National Park, and only recorded from one other locality in Victoria (the Snowy River).

SOLANUM COACTILIFERUM, J. M. Black. (Solanaceae).

Trans. Royal Soc. of S. Australia, vol. xxxiii., p. 224, 1909.

This may prove to be a local form of *S. esuriale*, Lindl., with four partite flowers developed as an abnormality. The narrow incurved leaves, tomentose covering, single flowers, and prickles also occur in *S. esuriale*, the prickles being especially well developed in desert specimens, but usually more slender than in the type specimen of *S. coactiliferum*. Both plants vary, however, in regard to the prickles.

SOLANUM HETERANDRUM, Parsh. "Pincushion Nightshade."

Swampy land near Tocumwal, New South Wales; C. B. Palmer, May, 1910.

This North American weed is already recorded as a naturalised alien in the North West and North of Victoria, but is apparently unrecorded for New South Wales.

VERBESINA ENCELIOIDES, Benth and Hook. (Compositae). "Crownbeard."

Euston, A. G. Briggs, March, 1910; Kerang, J. Moore, June, 1900; Junction of the Darling and Murray, R. Holding, 1891; L. Binance, C. Moore. April, 1888.

The two first localities are Victorian, the two last are in New South Wales. The plant is now permanently established as a naturalised alien in Victoria and New South Wales, and is very generally reported as being injurious or poisonous to stock, especially sheep. It is a native of North and South America now widely diffused over the warmer regions of the globe, and even occurring in gardens. No species of the genus is known to be poisonous, so that any injurious action the plant may have is probably a mechanical one.

ZOSTERA MARINA, L.

This is mentioned in the "Weeds and Poison Plants of Victoria," p. 91, on the strength of a specimen from Williamson as new to Victoria, possibly introduced. On further investigation I find that the specimens on which the *Zostera nana* of Bentham's Flora are based are mainly *Zostera marina*, being distinguished by their large size, broader leaves, more numerous veins, and seeds with longitudinal ridges or veins, instead of quite smooth as in *Z. nana*.

Zostera marina is found on flat, sandy or muddy shores around the whole coast of Australia, including Tasmania.

ZOSTERA NANA, F. K. Mertens.

Has apparently an equally wide range, but is less common. By some it has been considered a variety only of *Z. marina*, but the species can readily be distinguished by the characters given above. The Victorian Flora therefore includes three species of Zostera, *Z. marina; Z. nana* and *Z. tasmanica*. The last named is intermediate in size between *Z. marina* and *Z. nana*, and is distinguished from the latter by its pale seeds, broader floral sheaths and bractless flowers.

EXPLANATION OF PLATES.

PLATE XII.—HALGANIA ERECTA.

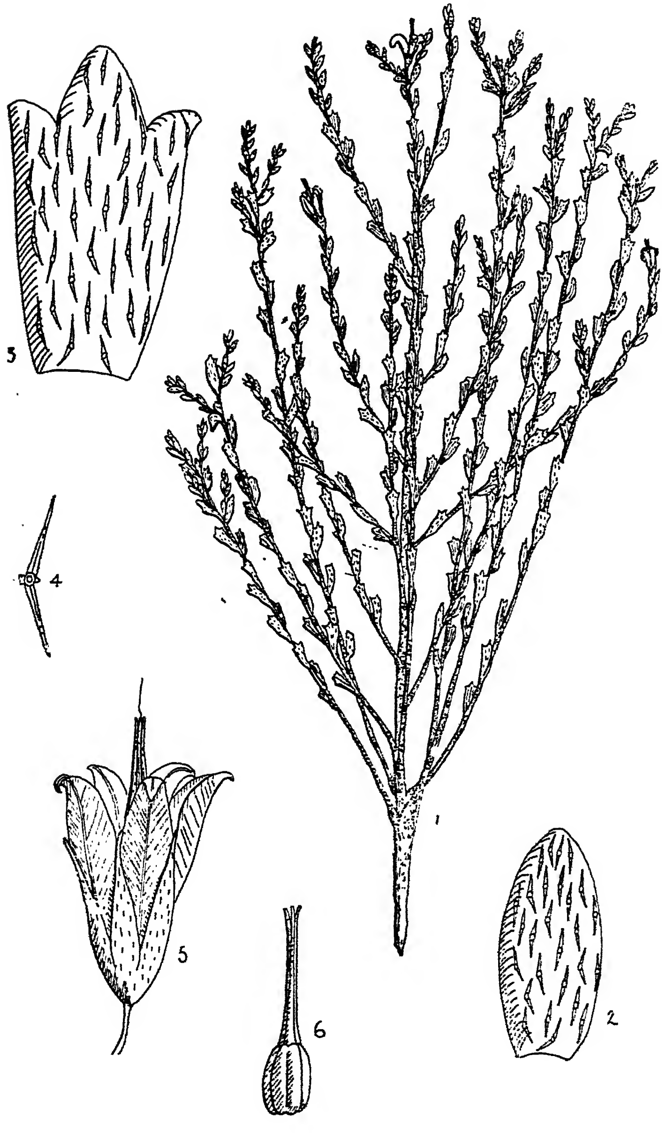
Fig. 1.—Plant of Halgania erecta Ewart and Rees (about natural size).

2.—Single young leaf showing hairs (enlarged).

Fig. 3.—Single old leaf showing hairs (enlarged).
4.—Single hair (much enlarged).
5.—Flower (enlarged).
6.—Anthers with processes (enlarged).

PLATE XIII.

Fig. 1.—Branch of Melaleuca neglecta.
2.—Flower of Melaleuca neglecta.
3.—Flower of Melaleuca pustalate.
4.—Petal of Melaleuca neglecta.
5.—Petal of Melaleuca pustulata.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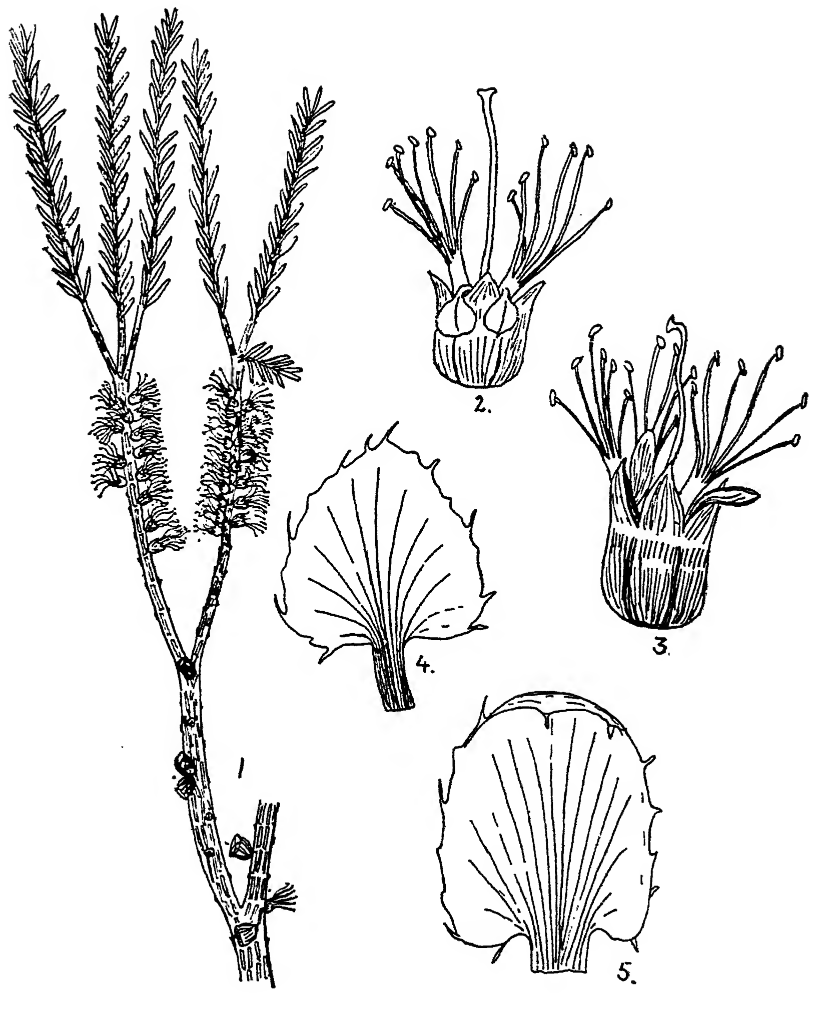
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[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. I., 1910.]

ART. XIII.—*Modern Improvements in Rock Section Cutting Apparatus.*

BY H. J. GRAYSON,

Geological Laboratory, University of Melbourne.

With Plates XIV.-XVII.).

[Read 9th June, 1910.]

I.—Introductory and General.

The cutting of Rock sections for class use and research work occupied a considerable proportion of the writer's time, and also entailed much labour, until a little over two years ago, when an effort was made to improve upon the apparatus at that time available for rock slicing. To attain this end, it was deemed best to build an entirely new machine, which should be electrically driven and embody all that was best in the earlier forms of lapidary's machine, while introducing such improvements and modifications as a considerable experience of rock slicing had shown would be advantageous.

At the outset, I may say that where only a *few* sections are likely to be required, a machine of any kind is not an absolute necessity. Given reasonably thin chips or flakes, such as can readily be obtained with a hammer, also plenty of time and energy, coupled with a fair amount of skill, and thin sections, in every way comparable with those made with the aid of mechanical devices, can be obtained. Hand work of this character is, however, both slow and laborious, and the preparation of any considerable number of sections becomes a serious undertaking.

In the early days of rock section making, the professional lapidary was usually resorted to, when a number of sections were required. Naturally, the machine used by him was the one first adopted by the Geologist, who, either from choice or necessity, prepared his own sections. The ordinary lapidary's

machine, though effective in his hands for his own particular work, is both crude and inconvenient for rock-section making.

A machine of this character was sent from London to the Melbourne University some 10 years ago. It was said to be a duplicate of one in use at the British Museum, and was then regarded as an up-to-date machine for rock slicing. I am unable to discover that this machine possesses any material advantage over the older types of similar apparatus.

Many years ago the late Mr. Jordan devised a simple and fairly convenient machine,[1] worked by means of a treadle. This machine, unlike that used by the lapidary, leaves both hands free for other manipulations—which is a decided convenience. This type of machine has since been modified, and improved, in respect to details, more especially by German petrologists, whose energies, however, seem to have been chiefly directed to devising elaborate and ingenious clamps for holding and orientating the specimen to be cut. Nearly all the more important German firms who cater for geologists now provide machines designed for driving either by foot or motor power. Generally speaking also, German rock-slicing apparatus is distinctly in advance of that made by English and American firms.

My reasons for building a machine, when so many other types were available to choose from, were mainly as follows:—

A fairly long experience in the preparation of rock sections had served to bring out some of the weak points of at least three machines with which I had worked. Moreover, I had adopted a process of section making, differing somewhat from that ordinarily followed, which made it possible largely to substitute slicing with diamond powder for grinding with emery, without material increase in cost, and with a great economy of time.

One of the chief drawbacks pertaining to the machines of which I had had experience, was that, ordinarily, they were speeded to run at from 300 to 500 revolutions per minute,

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1 A plan and section of the Jordan machine may be found in Rutley's "Study of Rocks," p. 64, 4th ed., 1888.

The ordinary lapidary's machine is figured in Holtzapffel's "Mechanical Manipulation," vol. iii., 1894 ed.

with slicing and grinding discs of 8in. diameter and less. Both experience and experiment had satisfied me, that, given an accurately made motor-driven machine, slicing and grinding discs 10in. in diameter might safely be speeded up to 1000 revolutions per minute, with a proportionate increase in efficiency. This conclusion, the results obtained have fully sustained.

Again, all the machines of English design and make, so far as my experience of them goes, are only provided with one revolving spindle or mandrel, which is invariably made to pass through the centre of both slicing and grinding discs, thus greatly limiting the efficiency of the latter. The single spindle also entails frequent changes from slicer to grinder; and further changes of the grinding laps, according to the differing grades of abrasives used; two of which, at least are always required. These frequent changes, of course, involve a considerable loss of time.

A further important defect — and this applies to both English and German machines—is that they have a far too limited top or bench space, hence both slicer and grinder are inconveniently crowded together, seriously hampering freedom of movement in both slicing and grinding operations. This crowding together of rapidly moving parts is also nearly always associated with inadequate protection to bearings and screws, etc., against the intrusion of emery or carborundum, the presence of which even for a short time is very destructive as well as difficult to remove.

In the machine I have constructed—and to which I may now briefly refer—I have endeavoured to fully provide against the several shortcomings I have named. The machine is speeded to run at close upon a thousand revolutions per minute. The slicing discs and grinding laps are 10in. in diameter. The latter are mounted like the face plate of a lathe; they run dead true, and have a clear surface for all operations. The laps and slicer are each separately mounted, with ample space for free movement, as well as with efficient guards, both with respect to the operator's clothes, the bearings and other moving parts: the necessity for such protection is obvious.

The motive power and running gear have both received careful consideration, so as to reduce noise and wear and tear to a minimum. Each grinder and the slicing discs are independently operated, and can be instantly thrown in or out of action by the mere push or pull of a conveniently placed handle. There are no idle running bands or belts; motion being communicated as required from a single overhead shaft by a specially designed clutch.

The net gain from these advantages, of which I give only the briefest outline, is that it has been made possible, as the result of actual trial, to slice a specimen suited for examination under the microscope—i.e., a section having an area of about one inch in diameter, and reduced to a thickness of less than .001 inch—the whole operation—slicing, grinding and mounting, occupying not more than 10 minutes—the specimen in question being a piece of granite. On no other machine, with which I am acquainted, is it possible to do this work within so short a time.

With regard to economy in working, the machine costs for motive power, running say 6 hours, not more than 6d. The cost for diamond powder, for slicing purposes—also deduced from actual trial—for a well charged disc, is not more than 1s. With this charge 95 slices, averaging 1in. in diameter and cut from about 20 different varieties of rock, ranging in hardness from granite to soft sandstone, were sliced without a re-charge of the disc.

Provision has been made, in addition to ordinary rock slicing, for cutting and grinding crystals to definite faces, and also for cutting and grinding parallel plates to a precise thickness.

More recently, a further modification has been made, adapting the machine to the cutting of serial sections, as, for example, in the case of a fossil imbedded in a piece of rock, etc. The method was first devised and described by Professor Sollas, of Oxford University, in the Transactions of the Royal Society of London for 1903. Professor Sollas obtained a special grant from the Royal Society for the construction of his machine, which was designed by the Reader of Mechanics—Mr. Jervis Smith, of Oxford University.

After reading Professor Sollas' description of this machine, I saw at once that, with no modification of the machine

my paper describes, other than the addition of a graduated circle and index point, it would be possible to undertake exactly the same kind of work as that for which the Oxford machine had been exclusively designed, and, as I think, with greater facility and convenience; the parallel clamp, which swings radially over the grinding disc of my machine, being already provided with the requisite adjustments for securely holding specimens requiring special serial treatment. Plate XVII., Fig. 1, shows the relations and simplicity of this apparatus. The radial clamp, holding a glass plate, to which a specimen is cemented, is seen in position over the grinding lap, its relation to the latter being controlled and adjusted by means of the graduated head on the top of the pillar to the right of the lap. Fuller details of this appliance will be found in Section 2 and in the explanation of the plates. Considerable experience of grinding operations requiring not only precision but delicacy of touch and freedom of manipulation over the surface of a rapidly revolving disc, convinces me that the requisite conditions for precise work are not as fully provided for as they might be by the slow and rigid traverse of Professor Sollas' machine. Moreover, his grinding laps are very small, being only 4in. in diameter, and driven by hand. The working of such a machine cannot but be inconvenient, seeing that one of the operator's hands is fully occupied with driving the machine, leaving only one hand free for controlling the various adjustments of the machine screws, and for applying water and the necessary abrasives, etc. These operations, if the machine is to be efficiently worked, requires the unremitting attention of more than one hand. The fact that Professor Sollas is fully satisfied with the results he obtains does not, I think, preclude the propriety of pointing out that equally good results may be obtained from simpler and much less costly adjustments, applied to an existing apparatus.

I may say that in addition to the various processes just described, my machine is admirably suited to all polishing operations; the comparatively high speed at which it is run rendering it particularly effective for this class of work.

The completed apparatus has now been in use for more than two years, and as it has fully met expectations I venture to

describe it with sufficient detail to enable others to benefit by my experience. As the method of rock slicing and section mounting are, in a measure, related and co-ordinated, it is necessary also to include a short account of the latter process.

2.—Structural Features of the New Machine.

A .detailed description of all the working parts of the machine, with plans to scale, is beyond the scope of this paper. Fortunately they are not, I think, necessary, as with the aid of photographs (Plates XIV. to XVII.) showing all the essential features of the apparatus and descriptions of less obvious features, it should be possible for an intelligent mechanic to construct a similar machine.

At the outset it is necessary to point out that in the building of the apparatus, I was strictly limited as to position and space.

Dealing with the several portions of the machine in order: —*Plate XIV.*, which may be regarded as equivalent to a sectional or front view, shows all the principal features of the apparatus, which is built into a corner of the workroom; the lathe in the foreground has no connection with the rock slicer, beyond being driven by the same motor. The three guard trays have been removed from the top of the rock machine table, in order to show the position and relation of the slicing and grinding-lap spindles, and of the several supports for rock holders and clamps.

Plate XV. may be regarded as a photograph in plan—i.e., looking down upon the machine. It shows to better advantage the relation of the working parts in running order, other than the driving mechanism, which is situated at some height above the machine, and is shown in detail in Plate XVI.

Plate XVII. (Figs. 1 and 2) serves to show the special appliances for serial section cutttng, parallel grinding, and work with the goniometer.

Reverting to Plate XIV., it will be seen that the base of the machine is a strongly built wooden bench or table with dimensions as follows:—Length, 7 feet; width, 2 feet 4 inches;

height, 3 feet 2 inches. The table top, which is $1\frac{3}{4}$ inches thick, is supported on a strong, well-braced framework, which is screwed to the wall of the building so as to insure complete freedom from vibration. The details of the construction of the table may be readily made out from an inspection of Plates XIV. and XVI., except that a supporting beam for the three spindles, which runs from end to end of the table, 9 inches below its surface, cannot of course be seen.

3.—Details of the Principal Mechanical Parts.

These are described in order, from right to left, as they appear in Plate XV. First comes the vertical revolving spindle of the slicer. This is made of mild steel—as indeed are all the spindles—15 inches long, by $1\frac{1}{8}$ inches in diameter. It passes through an accurately bored, flanged collar 3 inches long, screwed to the surface of the table. The lower end of this spindle, as also those of the grinding lap, is coned and fits into a corresponding metal socket, provided with an oil recess and protecting collar, which is screwed to the longitudinal beam of the table frame. The top of the spindle is threaded and carries carefully fitted collars and flanges for clamping the slitting discs.

Somewhat to the right of and behind the spindle of the slicer, is a rod of steel 1 inch in diameter and 18 inches long. The lower part of this rod, which is of somewhat greater diameter than the upper part, is coarsely threaded for 6 inches of its length, and screws into a long nut or socket fitted to the table, thus forming an adjustable support for the various specimen clamps. The rod has 3 inches or more of motion by means of a screw, and a further range is obtained with the aid of lock nuts sliding on the spindle itself.

The larger specimen holder is of the usual parallel screw clamp type, and will hold specimens up to 5 inches in diameter. Several interchangeable clamps are used; one of these, to be seen in the photograph (Plate XV.) is adapted to hold thick pieces of plate glass $3\frac{1}{2}$ x $1\frac{1}{2}$ inches (length and breadth) to which the ordinary microslips are attached. In addition

to its radial motion this carrier revolves axially, so that specimens to be sliced may be tilted at any convenient angle in relation to the slitting disc. This clamp also carries the goniometric crystal holder (shown in the front right corner of the tray) which permits of slicing or grinding in any desired direction. The device for maintaining a steady pressure or pull against the slicer comprises the usual cord, weights and pulleys, so placed as to be readily controlled.

Lubrication of the slicer is provided for by means of a drip-can and two pieces of sponge, one above and one below the disc held in position by a spring clamp.

Passing now to the grinding laps, of which there are two, seen in the centre of the table, it will be noted that they are screwed to the top of the spindles by means of a threaded boss below each plate. This mode of mounting allows the whole surface of the lap to be utilised, and is a convenience which has only to be once used to be appreciated. It not only allows the utmost freedom of movement, but also aids in the maintenance of a true surface on the lap for a long time. The spindles of the laps are somewhat shorter than that of the slicer, their length being 12 inches, so that the lap surface is about 3½ inches above the table, which is a convenient height for most operators. The mounting of the spindles is the same throughout, and has already been described. Dust and grit are excluded from the bearings by means of a special close-fitting collar in each case.

It will be seen that each grinding spindle is accompanied by a pillar which supports a clamping device in which specimens or blocks of glass are held so as to swing radially across the laps. This permits of parallel grinding to a precise thickness or definite form, and though not necessary for ordinary rock slicing, it has, as already explained, a variety of uses where precision is required.

The lower portion of each rod is threaded, and screws into a long socket let into the surface of the table. It can thus be accurately raised and lowered during use, so as to maintain a steady and even pressure upon the lap. It is also adapted to carry the goniometer which fits the special holder shown in the centre tray, and, as already indicated, as every part of the

machine is interchangeable if so required, a rapid transfer from one lap to another can be made. This correspondence between the several parts of the machine, and the facility of interchange which is thereby effected, results in the long run in a considerable saving of time.

The most effective laps, so far as my experience goes, are those of bronze containing a high percentage of copper, the aim being to secure a tough but not unduly hard lap. Pure copper laps would no doubt be better but they are difficult to cast and turn. Discs of lead and tin, and also of wood with felted surfaces are used in special cases and for polishing. A diameter of 10 inches is found to be convenient for most of these laps.

Tray-like shields, or mud guards are provided for each of the grinding laps as well as for the slicer. As will be seen, they are of square outline and conveniently large, the distance between the several spindles, 22 inches, permitting of this. The trays are made of stout galvanised iron 5 inches deep, and the upper edges are rounded and brass bound, forming clean and comfortable supports for the hands and arms of the operator. It should also be noticed that a space around each pillar or spindle is raised and carefully capped, so as to exclude dust and grit; this, in addition to the brass collars already noticed. The bearings of a machine running at a high speed, and upon which carborundum and other abrasives are to be freely used, cannot be too carefully protected from their intrusion: the life of the bearings is, in fact, directly proportional to the effective exclusion of the abrasives.

As already stated, the machine is motor driven, and as the method of connecting up is in some respects novel, I refer to it in some detail. An electrically driven one-horse-power motor serves to run the rock slicer, lathe, emery wheel and polisher, and has proved fully adequate for all requirements. As the motor runs at 1400 revolutions per minute, the main shafting, shown in Plate XVI., speeded down to about 300, a convenient speed for the driving wheels of both lathe and rock slicer. The usual method of gearing to a secondary shaft by means of belts and loose pulleys has been dispensed with, and a system of connecting directly to the main shaft adopted. This

permits of any single portion of the section apparatus being run separately; the remaining cords and pulleys being stationary. This effects a saving of power, and reduces the wear and tear upon the machine and belts or cords. The slicer, and each grinder and the polisher, are hence directly connected to the principal shafting, which runs loosely through each driving pulley, when the latter are not engaged. These pulleys are thrown into action, each by its own clutch, which is operated by a loose coned sliding collar on the main shaft. The sliding cone is moved directly from the work table by means of a rod, to the lower end of which a lever handle bar is rigidly screwed in a convenient position. At the top of the rod is a forked lever with adjusting screws fitting a groove in the sliding cone. By a twist of the handle bar below, the cone is forced under the lever of the clutch, which tightly engages the hub of the driving-wheel, and the lap or slicer, as the case may be, is brought into immediate action; the reverse movement of course instantly disengages the clutch, and the lap or slicer become stationary. The photograph (Plate XVI.), which shows a portion of the main shaft, driving wheels and clutches, will serve to make this portion of the mechanism sufficiently clear.

Connection between the driving wheel and each spindle, by means of a leather cord, is easily effected, the latter passing directly from wheel to spindle with the aid of guide pulleys only, these being secured to the under surface of the table.

Provision was originally made for two speeds, the change being effected by means of split pulleys on the spindle, which can easily be removed if required: but this is seldom necessary. A uniform speed of about 980 revolutions per minute has been found in every way satisfactory.

An extremely useful adjunct to the rock slicer is to be found in the small emery grinder attached to the same bench (seen to the left of Plate XV.) and driven in the same manner. It is speeded up to 2000 (or more) revolutions per minute, and has been found most convenient for a variety of work for which the larger machine is not so well adapted. It may be provided with various grinding and cutting wheels as well as polishers and brushes, which fit it for use upon fossils, and the

grinding and polishing of small mineral and other specimens. This is an addition to its varied usefulness in the workroom generally.

4.—Method of Slicing, Grinding and Mounting Rock Sections.

It is only by adopting and pursuing a methodical and co-ordinated series of operations that the full value of a machine similar to the one just outlined is fully secured. To this end I have adopted a system of working, the main features of which are embodied in the following brief summary of its salient points:—

A. *Charging the Slicers, Etc.*—This is invariably done with diamond powder, which it pays to crush, and sift from time to time during the operation. The sifting is easily done with the aid of several bits of glass tube about 1in. long and ¾in. wide, to one end of which, after grinding level, a bit of very fine bolting silk has been cemented. A slicer charged with properly graded diamond powder cuts faster and cuts longer than would be the case if the diamond were only ground to an almost impalpable powder in oil, as is frequently done: the former method is more effective as well as more economical.

Every slicer should be made to run "dead" true, and should be maintained in that condition. The greater the speed at which it is run, the more important it becomes that it should run truly. A slicer is always ineffective in proportion to its eccentricity. Too often the slicer is made to cut as long as it will cut; this is unsound, both in theory and practice.

With regard to charging a slicer, I find a chilled steel roller by far the most effective instrument for this purpose. It is better than any glass or agate implement; and, if properly made, is almost everlasting.

I have tried notching the slicers and charging the notches; it takes a long time to do this well—and it must be well done, or not at all. I was certainly rewarded with a slicer which cut well for a long time. Usually, however, I find a slicer charged in the ordinary way, that is by pressure of the diamond

powder into the smoothly turned edge of the soft iron slicer, gives a very satisfactory return for the small amount of time and trouble it requires to prepare. A hundred sections, each of which involves two cuts, at a cost of little more than a shilling, leaves nothing to complain of in the matter of expense. In slicing I use kerosene for lubrication, that is, if the rocks are compact and hard; for such rocks it is more effective than a soap emulsion, which of course must be used for soft and porous rocks. Any good soap makes an effective lubricant if properly dissolved. It need not be castile soap, which, like many other things, is not always what it is claimed to be.

B. *Grinding Powders.*—For this purpose only the finest graded carborundum is used. I also regrade what is ordinarily sold as graded material by the manufacturer. For example, FFF grade of the Niagara Falls Coy. can well be further separated into two or three grades. The coarsest of these is used upon the finest of the two machine laps; the remaining finer grades are used for finishing purposes by hand.

For the coarse lap, I find a fine but well graded powder is more effective than one that is coarse; indeed, the latter is simply thrown off a rapidly revolving lap. Two hundred and twenty grade carborundum is the coarsest I use for rough work. Ordinarily the series of laps comprises one coarse, one fine and one finishing—lap of slate for hand use only.

C. *Canada Balsam and Mounting Methods.*—Many people fail in their first attempts to cut and prepare sections satisfactorily, not through lack of perseverance or skill, but because they do not carefully prepare their balsamed slips beforehand. Good clean natural Canada balsam alone, if carefully prepared, will hold almost any rock securely to the end of the process of its preparation. The tenacity and range of hardness of the balsam may, however, be extended if a small quantity, not more than 1 to 3 per cent., of some clear and colourless organic oil is added to it. Poppy oil, Castor oil, Clove oil—even Linseed oil—are all suitable if used in the right proportions, and here experience alone is the best guide. Those who have not tried the addition of one of these oils, or something similar, will appreciate the improvement effected by them, if the addition is judiciously made.

One should not prepare too many balsamed slips at once, as they continue to dry slowly if not used, and eventually become too brittle. As to mounting, the specimen should be attached, in the first instance, to the slip upon which it is to remain. Transference to another slip is obsolete and unnecessary. It did well for thick sections, which were formerly much more common than they are, or should be, to-day. Again, the section and slip should not be flooded with balsam when about to attach the cover, for, besides making a sticky and unsightly mess, it is both wasteful and unnecessary. Prolonged heating of slip and section is not advisable, when one is mounting, with the object of driving out all the solvent from the balsam. The chances are, when this is attempted, that the section will be disturbed or float, and will tend to break up when putting down the cover, besides raising a crop of bubbles, which are very difficult to remove. It is a wiser and safer course to use no more balsam, and to apply no more heat than is necessary to bring the cover into close and uniform relationship with the whole of the section. An oven with a water jacket, maintained at about 40 deg. Cent., will, in from three to five days, complete the drying with perfect safety.

So much for what is general and more or less applicable to almost any successful process for the preparation and mounting of rock sections.

I will now briefly outline the process adopted with a collection of, say, 20 numbered rock specimens, which are ready for slicing. It is to be noted that I seldom prepare sections from detached slices, as these involve two parallel cuts and much subsequent grinding. It is twice as economical, both as to time and material, to slice off the rock close to the mounting slip, as by this method the smallest possible amount of material remains to be ground away. Two dozen 3 x 1 inch slips are cleaned and placed, the whole upon white blotting paper, spread on a sheet of asbestos, or a metal plate; this is laid upon a well filled sand bath, supported on a tripod over a bunsen flame. The heat from the latter is so regulated as not to discolour or char the paper below the slips. Each slip is now balsamed, using no more than experience has shown to be necessary for sections about one inch in diameter. While the balsam is "cooking,"

the specimens are successively clamped in the large specimen holder of the slicing machine, and a piece, large enough for a section, is sliced away; the whole 20 being thus treated. Meantime, the balsamed slips will have become sufficiently hardened. Each slip should be separately tested, when cool, with forceps or knife; the hardened balsam should indent with moderate pressure without splintering.

The sliced face of each specimen is now, for a few seconds, held upon the finest revolving lap, which is fed with F.F. carborundum, and moistened with water containing about 1/5th of its volume of Glycerine, which maintains a rapidly revolving disc sufficiently moist, without excess, for a long time. Each specimen requires only a brief treatment, and if the lap is in first class order no further preparation should be required. Usually, however, it is safer to give each specimen a few sweeps by hand, upon a slate or glass lap, the surface of which should be accurately true or flat. After washing and drying, the specimens are ready for attachment to the balsamed slips. This is done by heating them sufficiently to occasion discomfort when held against the hand for a few seconds; the slip being correspondingly heated, the specimen is pressed home on the slip, taking care to exclude all air bubbles. As each slide is dealt with it is placed on a second plate of glass ($3\frac{1}{2}$ x $1\frac{1}{2}$ in. x 5/16th in. thick, the blocks being strictly uniform), and heated to melt the beeswax, which is used to hold the slip in position during its subsequent treatment. After the entire series has thus been treated and allowed to cool, each glass plate or block in turn is clamped in the special holder, and the slicer passed through the rock close to the glass of the mounting slip. With everything in good order, this may be done to within .5 mm.; the thickness being regulated by means of two strips of thin sheet iron, held in position on the slip while the cut is being started.

The series having been sliced, each section is ground to within .1 mm. on the coarse grinding lap, using F carborundum, or certainly not a coarser grade than 220. After washing, the grinding is completed on the finest revolving lap, and if the latter is true and the operator experienced, scarcely any further grinding will be required. With a sufficiently finely graded

powder, there should be no scoring or scratches; the latter, if present, being due to fragments of too coarse a powder, or to its use in too limited a quantity, thus allowing the specimen to come in contact with the metal of the lap. As a rule, and for safety, it is wiser to give the last touches by hand upon a suitable lap of slate or glass, using only the finest washed powder.

The whole process is not so long, or so complicated as any description must necessarily seem to imply. With the aid of the machine described, and given balsamed slides in readiness, I find it possible to complete single slides in 10 to 15 minutes; the finished section, in area, uniformity and thinness, leaving little to be desired. Furthermore, with a series of rocks—and it is usual to treat a number together—there is a corresponding gain in time, throughout the several operations. Naturally too, and perhaps more particularly with the type of machine just described, individual experience, dexterity of manipulation and judgment, are material factors affecting the final result, both as to time and quality of work. Compared with the older type of machine, both hand and treadle, there can be no question as to the net gain, in time and labour, both of which are important. There is, too, I think, an equivalent improvement in the average quality of the finished product. On these grounds I hope the publication of this brief description will prove useful to all who are interested in the preparation of rock sections.

EXPLANATION OF PLATES XIV.-XVII.

Plate XIV.

New Rock-Slicing Machine, Melbourne University. Side view, showing slicing disc and grinding laps, and the supporting rods for the various clamps and specimen holders. The levers which operate the driving mechanism can be seen above and somewhat behind the spindles. The guard trays have been removed, so as to show the several parts of the machine more clearly. The lathe in the foreground is independent of the rock machine.

Plate XV.

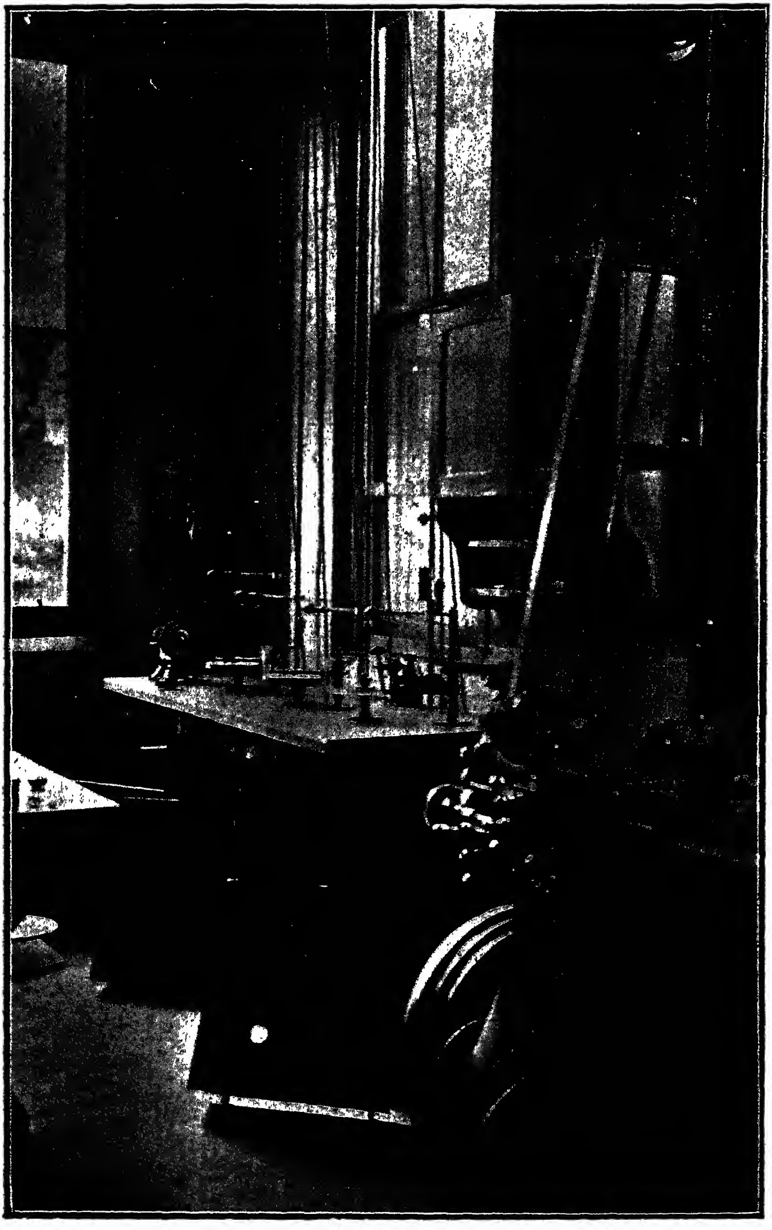
New Rock-Slicing Machine, Melbourne University. Top view or photograph in plan serving to show the machine in working order. To the right of the view the slicer and one clamp are seen in position for slicing. A second clamp, for holding massive rocks, is shown on the extreme right; while the goniometer as adjusted for the slicer is seen in the right front corner of the guard tray. The two grinding laps, with supports and clamp adjustments for specimens, follow in order to the left of the slicer. Ordinarily, in the preparation of rock sections, the clamps above the grinding laps are not required; but in all operations involving precision their use is indispensable. The emery wheel and polisher referred to in the paper are situated on the extreme left of the table. A graduated 60 inch scale, the divisions on which are unfortunately not reproduced, lies along the front of the guard trays.

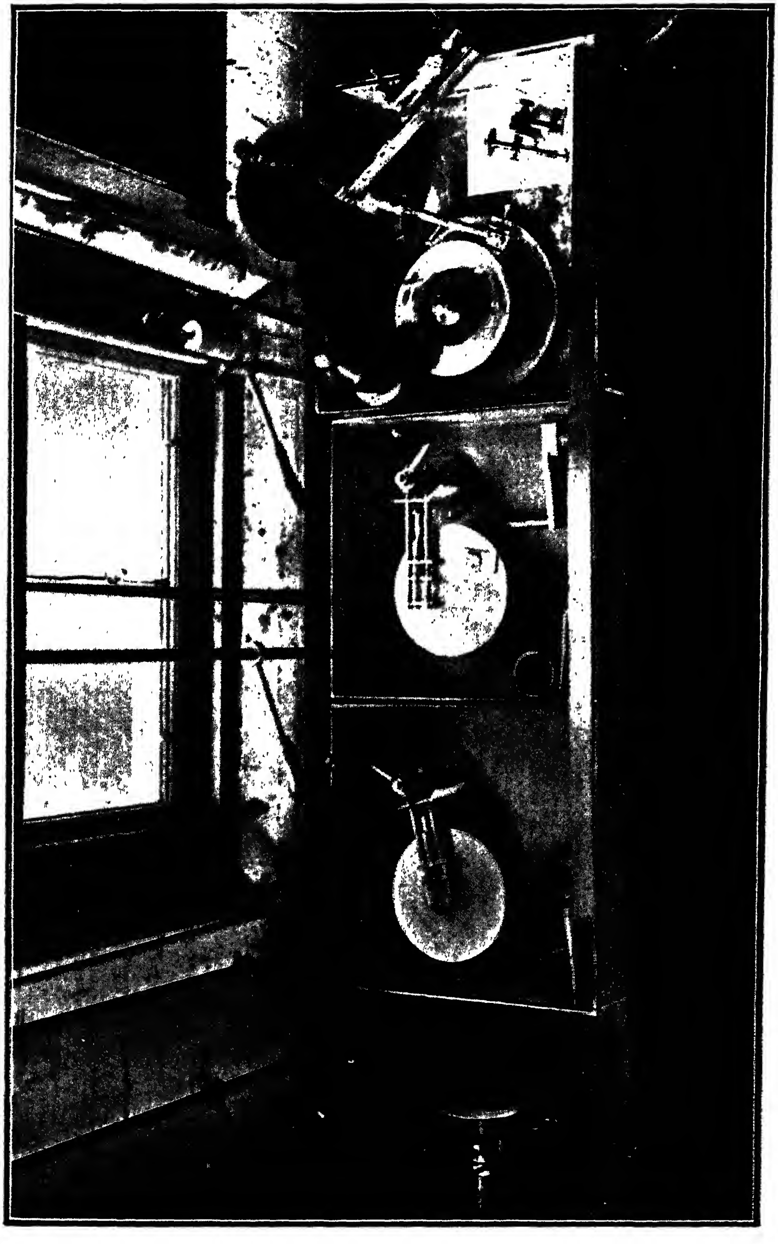
Plate XVI.

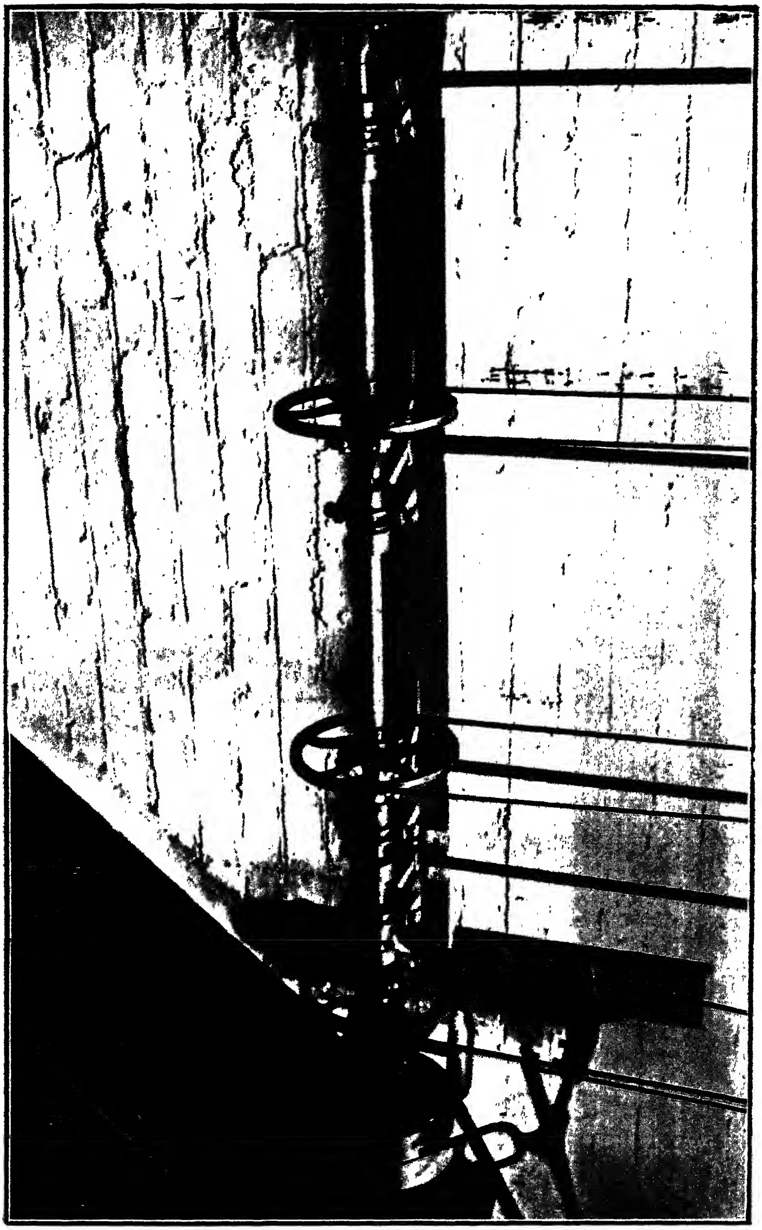
New Rock-Slicing Machine, Melbourne University. Driving mechanism in detail. The usual fast and loose pulley driven by the motor are seen upon the main shaft on the left of the photograph. To the right of these, the shaft passes successively through each driving pulley, which, in turn, connects with the machine below by means of a leather band. The pulleys, ordinarily stationary with the shaft running through them, are brought into action by the lever which forces the cone on the left under the lever of the clutch attached to the hub of each pulley.

Plate XVII.

New Rock Slicing Machine, Melbourne University. Fig. 1, Arrangement for serial section cutting. Fig. 2, Gonimeter attachment in position for grinding facets, etc. In Fig. 1, in addition to the usual clamp, which swings radially over the grinding lap, a graduated disc is shown. This disc is keyed to







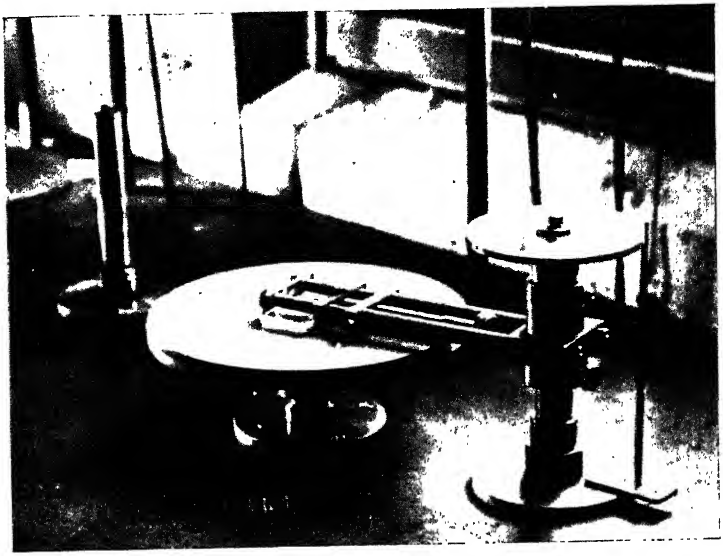


Fig 1

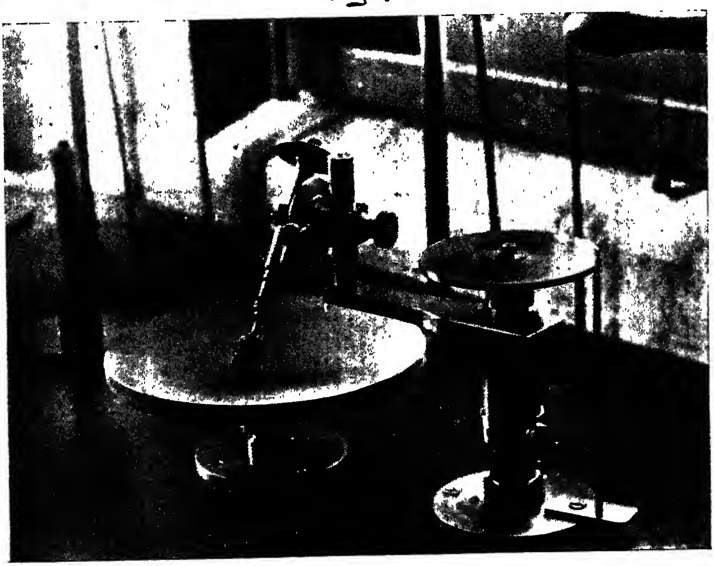


Fig 2

the top of the clamp support, so as to be removed and replaced at will without altering its relation to the index pointer. The rod is also provided with a lock nut so that perfect rigidity can be maintained during the operation of grinding. The graduation of the disc is such that the rod may be raised or lowered the $\frac{1}{1200}$ of an inch, or any greater fraction or value up to about 2 inches. One can thus successively grind away definite amounts from a fossil or thick section, and reproduce, by drawings or photo graphs, the varying features revealed during the operation, and this without disturbing or detaching the specimen from the clamp.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Part I., 1910.]

Art. XIV.—*On some New Species of Victorian Marine Mollusca.*

By J. H. GATLIFF and C. J. GABRIEL.

(With Plates XVIII., XIX.)

[Read 14th July, 1910.]

This paper includes description and figures of the following species:—

Columbella remoensis, sp. nov.
Columbella franklinensis, sp. nov.
Leiostraca joshuana, sp. nov.
Cingulina magna, sp. nov.
Cingulina rhyllensis, sp. nov.
Cyclostrema microscopica, sp. nov.
Saxicava subalata, sp. nov.

We have to thank Mr. E. C. Joshua for his skilful work in preparing the photographs that the plates are taken from.

Columbella remoensis, sp. nov. (Pl. XVIII., Figs. 1, 2).

Shell small, of five and a half whorls; apex consisting of two smooth whorls, with a central brown spot at the summit, the remaining whorls are ornamented with a peripheral band of rounded gemmules. There is a second band just above the suture of much finer beads, and they are about four times as numerous. The body whorl has a third similar fine row, commencing just below the posterior portion of the columella, and running round the dorsum to the edge of the outer lip. Colour white, the ornament opaque, on a translucent ground.

Mouth lanceolate, channel well open, slightly everted at its termination.

Dimensions of Type.—Length, 3.75; breadth, 1.50 mm.

Locality.—San Remo, Western Port.

Obs.—This is a very beautiful and ornate species. Dr. J. C. Verco, of Adelaide, has sent us specimens of this shell, obtained by him from St. Vincent's Gulf, South Australia.

Type in Mr. Gatliff's collection.

Columbella franklinensis, sp. nov. (Pl. XVIII., Fig. 3).

Shell small, smooth, acuminate, of six whorls; the body whorl is inflated, and is rather more than half the length of the shell. Whorls convex, suture well defined. Fine ascending striae encircle the base, and cease at the columella; base somewhat restricted, with slightly reverted snout. Outer lip thickened, shouldered at its junction with the body whorl, smooth interiorly. Mouth lanceolate. Colour yellowish white, somewhat translucent.

Dimensions of Type.—Length, 3; breadth, 1.25 mm.

Locality.—Point Franklin, Portsea, Port Phillip, in shell sand.

Obs.—The shell is the smallest of our smooth forms that we have in the genus; its chief distinguishing character is its shape, which differs from that of any other found here.

Type in Mr. Gatliff's collection.

Leiostraca joshuana, sp. nov. (Pl. XVIII., Fig. 4).

Shell minute, fusiform, smooth, glassy, and sufficiently transparent to discern the axial pillar through the whorls. Whorls eight, including the apical, which are a trifle more vitreous than the rest. Sutures not impressed, and merely define the whorls. The whorls are without varices, but the last three are ornamented with interrupted, ziz-zag, orange-coloured markings, more pronounced on the body whorl, and which may be plainly seen through the aperture. Aperture pyriform, effuse anteriorly, outer lip thin, and with a callus on body whorl; columella margin nearly straight.

Dimensions of Type.—Length, 3; breadth, 1 mm.

Locality.—San Remo, type locality (T. Worcester); Portland (T. Worcester); Portsea, Por Phillip; Shoreham, Western Port.

Obs.—*L. acutissima*, Sowb., and *L. lodderae*, Hedley, are the other Victorian representatives of the genus, but the present one may be easily separated by its broader, fusiform character, and the zig-zag markings. It somewhat recalls *L. constellata*, Melvill, from Aden. We have named this after Mr. E. C. Joshua, the artist who figured it.

Type in Mr. C. J. Gabriel's collection.

Cingulina magna, sp. nov. (Pl. XIX., Fig. 8).

Shell gradually tapering. Shining. Whorls eleven, including protoconch of two smooth whorls, the apex small, asymmetrical. Whorls slightly convex; the earlier ones are transversely puckered at the shoulder. The penultimate whorl is encircled by about six irregularly spaced, narrow, shallow grooves, which gradually fade out as they ascend. Suture incised. Base rounded. Outer lip thin, continuous to where it joins the columella, slightly reflected at the junction. Mouth pyriform. Colour, uniformly creamy white.

Dimensions of Type.—Length, 10.50; breadth, 2.75 mm.

Locality.—Shoreham, Western Port.

Obs.—May be distinguished from our other species chiefly by its greater size.

Type in Mr. Gatliff's collection.

Cingulina rhyllensis, sp. nov. (Pl. XIX., Fig. 9).

Shell solid, attenuate, cream-colour, shining. Whorls eight, including a smooth, bulbous, two-whorled protoconch.

Whorls exclusive of apex, flatly convex, separated by a well-defined, deeply impressed suture; sculptured with equidistant flat-topped spiral lirae, six on the penultimate, and increasing to eleven on the body-whorl; this encircling sculpture being crossed by faint, oblique axial ribs, more plainly seen on the earlier whorls. Distinctly visible are the lines of growth. Base imperforate, sloping and with the lirae a little more pronounced than the preceding. Aperture pyriform, interior shining; columella slightly concave; labium reflexed, the outer lip being somewhat damaged.

Dimensions of Type.—Length, 8.5; breadth, 2.5 mm.

Locality.—Dredged between Phillip and French Islands, Western Port, 5—7 fathoms.

Obs.—Distinguished from *Cingulina spina*, Crosse and Fischer, by its more numerous and flat-topped lirae.

Type in Mr. C. J. Gabriel's collection.

Cyclostrema microscopica, sp. nov. (Pl. XVIII., Figs. 5, 6, 7).

Shell very minute, of four whorls, rapidly increasing in size, rounded. The apex is smooth, and is succeeded by lirate whorls, the lirae numbering about five on the penultimate whorl, which increase in number by intercalation to about fifteen at the outer edge of the lip. Deeply umbilicated. Mouth circular, outer lip simple. White, semitranslucent.

Dimensions of Type.—Diameter, .75 mm.

Locality.—Shoreham, Western Port (T. Worcester).

Obs.—An interesting minute form.

Type in Mr. Gatliff's collection.

Saxicava subalata, sp. nov. (Pl. XIX., Figs. 10, 11, 12).

Shell white, inflated, somewhat angular; sub-equal, inaequilateral. Valves slightly gaping anteriorly. Beaks depressed, slightly incurved, produced anteriorly. Dorsal margin straight, somewhat alate posteriorly. Post-dorsal border curved. Ventral margin straight. Post-ventral margin subangulate, anterior end rounded. From the umbo to the posterior end runs an oblique, well-defined ridge, steep on dorsal side and becoming more rounded as it approaches the ventral margin: the posterior slope thus formed covering about one-third of the entire shell. Ligament external, well developed, and faintly darker than the epidermis.

Sculpture.—At the umbonal region appear very fine lines of growth, which develop into irregular, somewhat undulating rugae. Besides this concentric sculpture, the whole surface is studded with minute granular excresences developing with age and approaching more the form of tubercles, and which may be plainly seen from the interior of the shell. These are arranged roughly parallel with the rugae. When portions of the shell are examined under a high power (preferably a ninth), these granules can be focussed from both the inner surface below which is seen the striated vitreous layer, and from beneath the external layer; the granules then resolve themselves into pillars which extend from surface to surface, and are more or less cylindrical. Sometimes the granules coalesce and

form bundles of three or more. The shell is invested with a very thin olivaceous epidermis. Interior somewhat iridescent. Muscular impressions strong, the anterior oblong and the posterior subcircular. Pallial line not sinuated. Hinge simple, the characteristic curved tooth of the juvenile form having become almost obsolete. The post-dorsal edge of valves is dehiscent.

Dimensions of Type.—Length, 7.5; breadth, 3.75; depth of single valve, 1.5 mm.

Locality.—Dredged off Point Cook, Port Phillip, 8 fathoms (type locality). Type taken alive. Dredged off Portsea, Port Phillip, Frankston and Dromana (T. Worcester).

Obs.—In the young condition, the hinge exhibits a rather prominent, much curved tooth in the right valve, with a corresponding cavity in the left, thus presenting a character differing in its entirety from the senile form. This is characteristic of the genus *Saxicava*, and it was the young form of *S. rugosa*, Linn., where Daudin erred in erecting his genus *Hiatella*. Superficially the species much resembles a North American palaeozoic shell, *Modiomorphà subalata*, Conrad, but the hinge alone severs it from that genus. Like other representatives of *Saxicava*, the present one is variable, several specimens showing more pronounced alation. The angular form and granular surface serve as useful recognition marks, but with beach-worn specimens, the latter is difficult to discern. The irregular dehiscence of the valve-edges is not seen on all the specimens, and is not confined to the post-dorsal edge.

Type in Mr. C. J. Gabriel's collection.

EXPLANATION OF PLATES XVIII., XIX.

Figs. 1, 2 - - -	Columbella remoensis, sp. nov.
„ 3 - - -	Columbella franklinensis, sp. nov.
„ 4 - - -	Leiostraca joshuana, sp. nov.
„ 5, 6, 7 - -	Cyclostrema microscopica, sp. nov.
„ 8 - - -	Cingulina magna, sp. nov.
„ 9 - - -	Cingulina rhyllensis, sp. nov.
„ 10, 11, 12 -	Saxicava subalata, sp. nov.

All figures variously magnified.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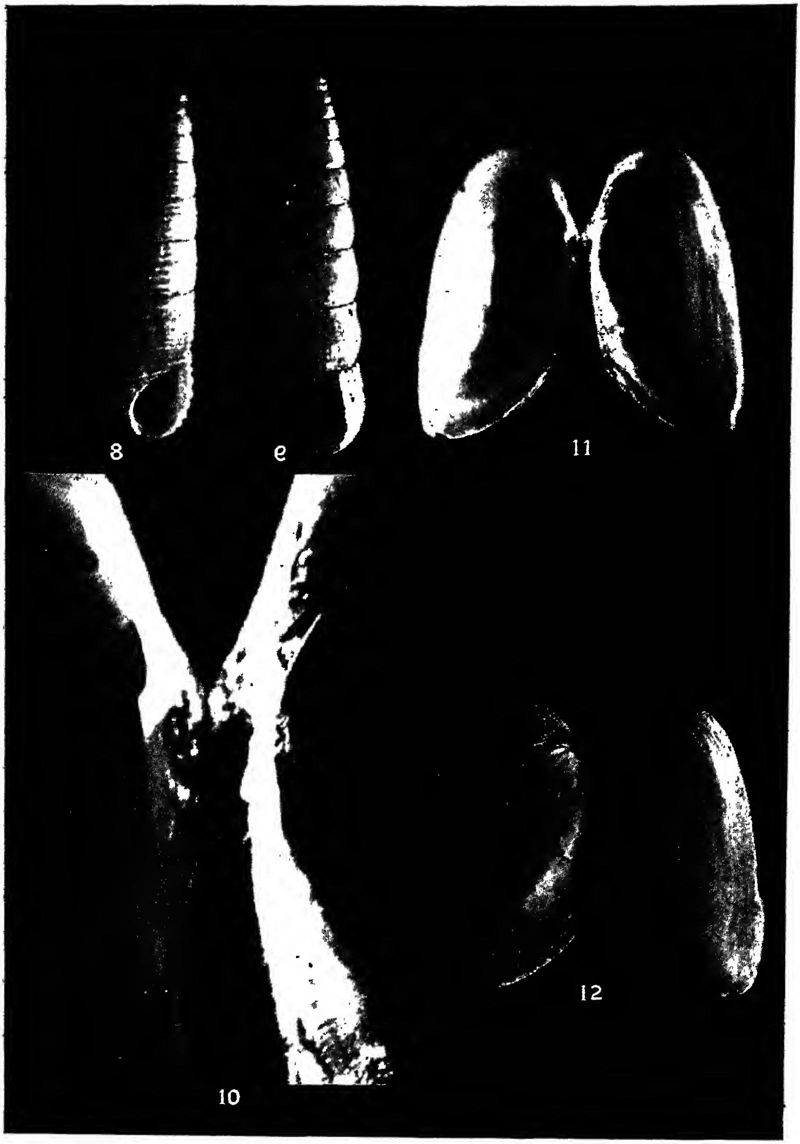
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[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910].

Art. XV.—*Additions to the Catalogue of the Marine Shells of Victoria.*

By J. H. GATLIFF and C. J. GABRIEL.

[Read 14th July, 1910.]

This paper adds 52 species to our fauna, including the seven new species in the preceding paper, bringing the total to 919. Twenty-five of them were obtained by the Commonwealth Trawler "Endeavour" off Wilson's Promontory, comprising some forms previously obtained by Mr. C. Hedley at Mast Head Reef, Capricorn Group, Queensland.

A notable occurrence is that of *Murex damicornis*, Hedley, the type of which was dredged by him on the coast of New South Wales.

Three new genera are added, namely, *Imbricaria*, *Cuspidaria*, and *Arcoperna*.

In our next paper we purpose making some remarks on species already catalogued.

Murex damicornis, Hedley.

1903. Murex damicornis, Hedley. Mem. Aust. Mus., vol. iv., p. 378, f. 92, in text.

Hab.—15 miles south-west of Gabo Island, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Length, 56; breadth (without the spines), 23 mm. It much resembles *M. denudatus*, Perry, but has much longer spines.

Trophon laminatus, Petterd.

1884. Trophon laminata, Petterd, Jour. of Conch., vol. iv., p. 136.

1901. Murex laminatus, Tate and May. P.L.S. N.S.W., vol. xxiv., p. 352, pl. 23, f. 3.

1903. Trophon laminatus, Hedley, Mem. Aust. Mus., vol. iv., p. 379.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Length, 6; breadth, 3.5 mm.

Genus Imbricaria, Schumacher, 1817.

IMBRICARIA PORPHYRIA, Verco.

1896. Imbricaria porphyria, Verco. T.R.S. S.A., p. 227, pl. 8, f. 5, 5a.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Size of Type.—Length, 10; breadth, 5.75 mm.

Obs.—Dr. Verco remarks, "P. Fischer, in his Manuel de Conchyliologie, p. 614, says *Imbricaria* of Schumacher has no operculum. The shell I describe has one, but I leave the discussion of its generic location for a future communication." It also has an acute outer lip, in *Imbricaria* this is thickened.

MARGINELLA STANISLAS, T. Woods.

1877. Marginella stanislas, T. Woods. P.R.S. Tas., for 1876, p. 133.

1901. Marginella stanislas, Tate and May, P.L.S., N.S.W., p. 362, pl. 26, f. 82.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Length, 6; width, 2.66 mm.

MARGINELLA AGAPETA, Watson.

1886. Marginella (Glabella) agapeta, Watson, Chall. Zool., vol. xv., p. 266, pl. 16, f. 9.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—A small white shell, triplicate, outer lip finely dentate.

COLUMBELLA REMOENSIS, Gatliff and Gabriel.

1910. Columbella remoensis, Gatliff and Gabriel. Ante page 82.

COLUMBELLA FRANKLINENSIS, Gatliff and Gabriel.

1910. Columbella franklinensis, Gatliff and Gabriel. Ante page 83.

COLUMBELLA GEMMULIFERA, Hedley.

1907. Pyrene gemmulifera, Hedley. P.L.S. N.S.W., vol. xxxii., p. 510, pl. 19, f. 44.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Mr. Hedley describes the sculpture of the second whorl as having fine radial riblets, our specimens are much worn, and the second whorl is smooth, and the shells are larger than the type, so possibly ours may be a variety. Dr. J. C. Verco, of Adelaide, has forwarded to us similar specimens dredged by him in 40 fathoms off Beachport, South Australia.

CANCELLARIA (ADMETE) STRICTA, Hedley.

1907. Admete stricta, Hedley. Rec. Aust. Mus., vol. vi., p. 295, pl. 54, f. 10.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Length, 4.5; breadth, 1.76 mm.

DRILLIA TRICARINATA, T. Woods.

1878. Drillia tricarinata, T. Woods, P.L.S., N.S.W., vol. ii., p. 265.

1901. Drillia tricarinata, Hedley. Rec. Aust. Mus., vol. iv., p. 23, f. 3.

1903. Drillia tricarinata, Hedley. Mem. Aust. Mus., vol. iv., p. 389, f. 104.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—The type is 6 mm. in length, the single specimen before us is 8.50 mm. in length, and of a brown colour.

MANGILIA GATLIFFI, Verco.

1909. Mangilia gatliffi, Verco. T.R.S. S.A., vol. xxxiii., p. 312, pl. 28, f. 9.

Hab.—Dredged off Inverloch. about eight fathoms (F. H. Baker).

Obs.—Size of Type: Length, 5.25 mm.; of aperture, 2.25 mm.; breadth, 2.25 mm. It is described as being white and solid, and finely spirally sulcate. Our single specimen is suffused with a light-violet tint.

MANGILIA INSCULPTA, Adams and Angas.

1863. Mangilia insculpta, Adams and Angas. P.Z.S., Lond., p. 420, pl. 37, f. 8.

1909. Mangilia insculpta, Verco. T.R.S. S.A., vol. xxxiii., p. 315.

Hab.—Port Albert (T. Worcester).

Obs.—Size of Type: Length, 6.25 mm.; breadth, 2.25 mm.; closely resembling *M. delicatula*, T. Woods.

MANGILIA FALLACIOSA, Sowerby.

1896. Daphnella (?) fallaciosa, Sowerby. P. Mal. S. Lond., vol. ii., p. 26, pl. 3, f. 7.

1909. Mangilia fallaciosa, Verco. T.R.S., S.A. vol. xxxiii., p. 319.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Length, 10 mm.; breadth, 3.25 mm.

MANGILIA HILUM, Hedley.

1908. Mangelia hilum, Hedley, P.L.S. N.S.W., vol. xxxiii., p. 471, pl. 9, f. 17.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Length, 3.85; breadth, 1.25 mm.

DAPHNELLA BITORQUATA, Sowerby.

1896. Daphnella bitorquata, Sowerby. P. Mal. Soc., Lond., vol. ii., p. 27, pl. 3, f. 9.

Hab.—San Remo, Western Port,

Obs.—Size of Type: Long, 4.50; diam., 2.50 mm. Dr. Verco (T.R.S. S.A., 1909, p. 324) considers the above species to be a variety of *D. tasmanica*, T. Woods. We regard them as being distinct.

DAPHNELLA LAMELLOSA, Sowerby.

1896. Clathurella lamellosa, Sowerby. P. Mal. Soc., Lond., vol. ii., p. 28, pl. 3, f. 11.

1909. Daphnella lamellosa, Verco. T.R.S. S.A., vol. xxxiii., p. 325.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Long, 4; diam., 2 mm.

SCALA ACANTHOPLEURA, Verco.

1906. Scala acanthopleura, Verco. T.R.S. S.A., vol. xxx., p. 145, pl. 4, f. 8.

Hab.—Port Albert (T. Worcester).

Obs.—Size of Type: Length, 4.1; breadth, 2.6 mm.

STYLIFER BRAZIERI, Angas.

1877. Stylifer brazieri, Angas. P.Z.S., Lond., p. 173, pl. 26, f. 12.

1886. Stylifer brazieri, Tryon, Man. Conch., vol. viii., p. 291, pl. 71, f. 47.

Hab.—Bass Strait, Commonwealth Trawler "Endeavour."

LIPPISTES ZODIACUS, Hedley.

1907. Lippistes zodiacus, Hedley. P.L.S. N.S.W., vol. xxxii., p. 502, pl. 18, f. 30.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Length, 1.6; breadth, 0.85 mm. Mr. C. Hedley has examined our shell, and states it is exactly like the type which was obtained at Mast Head Reef, Capricorn Group, Queensland, and that he has since identified the species from Sydney Harbour.

LEIOSTRACA JOSHUANA, Gatliff and Gabriel.

1910. Leiostraca joshuana. Gatliff and Gabriel. Ante page 83.

CINGULINA MAGNA, Gatliff and Gabriel.

1910. Cingulina magna, Gatliff and Gabriel. Ante page 84.

CINGULINA RHYLLENSIS, Gatliff and Gabriel.

1910. Cingulina rhyllensis, Gatliff and Gabriel. Ante page 84.

TRIPHORA REGINA, Hedley.

1903. Triphora regina, Hedley. P.L.S. N.S.W., vol. xxvii., p. 608, pl. 32, f. 21.

1909. Triphora regina, Verco. T.R.S. S.A., vol. xxxiii., p. 285.

Hab.—West Head, Flinders.

Obs.—Size of Type: Length, 5 mm.; breadth, 1.5 mm. Mr. Hedley remarks: "I venture to describe this species from a single specimen, mutilated at each extremity, because the orange thread on each whorl will render possible the recognition of any fragment. The contour and sculpture are also sufficiently distinct from any species known from this coast." Probably the colour had faded on this specimen, as ours are light brown, as is also the protoconch, although it is imperfect in our examples.

TRIPHORA ALBOVITTATA, Hedley.

1903. Triphora albovittata, Hedley. P.L.S. N.S.W., vol. xxvii., p. 609, pl. 32, f. 26, 27.

1909. Triphora albovittata, Verco. T.R.S. S.A., vol. xxxiii., p. 285.

Hab.—Shoreham, Western Port.

Obs.—Size of Type: Length, 4.8 mm.; breadth, 1.5 mm. Apex brown of four whorls, remaining whorls yellow, with the exception of the upper row of granules, which are continuously white.

TRIPHORA ALBOVITTATA, Hedley, var. MAMILLATA, Verco.

1909. Triphora albovittata, Hedley, var. mamillata, Verco. T.R.S. S.A., vol. xxxiii., p. 285.

Hab.—Portsea, Port Phillip.

Obs.—Dr. Verco remarks: "Instead of having the elongate four-whorled protoconch of the type, it has a mamillate two-whorled apex."

TRIPHORA ARMILLATA, Verco.

1909. Triphora armillata, Verco. T.R.S. S.A., vol. xxxiii., p. 283, pl. 22, f. 5.

Hab.—Ocean Beach, Point Nepean; San Remo, Western Port (T. Worcester).

Obs.—Size of Type: Length, 7.9 mm.; breadth, 2.2 mm. Four whorled protoconch coloured light brown, remainder of the shell white, with the exception of the fifth and sixth whorls, which are dark brown.

TRIPHORA CANA, Verco.

1909. Triphora cana, Verco. T.R.S. S.A., vol. xxxiii., p. 289, pl. 23, f. 2-4.

Hab.—Portsea, Port Phillip.

Obs.—Size of Type: Length, 7.1 mm.; breadth, 2.1 mm. Two whorled slightly mamillate protoconch, it and the succeeding four whorls are white, the remainder of the shell light brown.

TRIPHORA SPINA, Verco.

1909. Triphora spina, Verco. T.R.S. S.A., vol. xxxiii., p. 280, pl. 22, f. 2, 3, 4.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Length, 12.4; breadth, 1.9 mm.

TRIPHORA GEMMEGENS, Verco.

1909. Triphora gemmegens, Verco. T.R.S. S.A., vol. xxxiii., p. 290, pl. 23, f. 7, 8.

Hab.—Dredged, about six fathoms, between Phillip and French Islands, Western Port.

Obs.—Size of Type: Length, 7.1; breadth, 1.8 mm.

LIOTIA PETALIFERA, Hedley and May.

1908. Liotia petalifera, Hedley and May. Records Aust. Mus., vol. vii., p. 116, pl. 22, f. 6, 7, 8.

Hab.—Port Albert (T. Worcester). Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Height, 0.6; diameter, 1.25 mm A minute white shell resembling *Cyclostrema johnstoni*, Beddome, which species has about 35 transverse ribs on the body whorl, in *L. petalifera*, they number 24. Our identification has been kindly confirmed by Mr. Hedley.

CYCLOSTREMA DELECTABILE, Tate.

1899. Cyclostrema delectabile, Tate. T.R.S. S.A., vol. xxiii., p. 216, pl. 7, f. 4.

Hab.—Ocean Beach, Point Nepean.

Obs.—A small white shell. Size of Type: Major diameter, 1.66; minor diameter, 1.1; height, .95 mm. Sculpture fine, reticulated.

CYCLOSTREMA DENSELAMINATUM, Verco.

1907. Cyclostrema denselaminatum, Verco. T.R.S. S.A., vol. xxxi., p. 306, pl. 29, f. 9.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—A small opaque white shell. Size of Type: Major diameter, 1.55; minor diameter, 1.4; height, 1.1 mm. Similar to the preceding species, but it has stronger axial threads.

CYCLOSTREMA MICROSCOPICA, Gatliff and Gabriel.

1910. Cyclostrema microscopica, Gatliff and Gabriel. Ante page. 85.

RISSOA JACKSONI, Brazier.

1886. Rissoa badia, Watson (non Petterd, 1884). Chall. Zool., vol. xv., p. 612, pl. 46, f. 3.

1894. Rissoia jacksoni, Brazier. P.L.S. N.S.W., vol. ix. (2nd series), p. 695.

1899. Rissoia jacksoni, Tate. T.R.S. S.A., vol. xxiii., p. 233.

Hab.—Kilcunda; San Remo (T. Worcester).

RISSOA SUBFUSCA, Hutton.

1873. Barleeia subfusca, Hutton. Cat. N.Z. Moll., p. 28.

1873. Rissoina purpurea, Hutton. Id. p. 29.

1880. Rissoina subfusca, Hutton. Man., N.Z. Moll., p. 80.

1880. Rissoina purpurea, Hutton. Id. p. 80.

1898. Rissoia (Cingula), subfusca. Suter, P. Mal. S., Lond., vol. iii. p. 4.

Hab.—Dredged between Phillip and French Islands, Western Port; Portsea, Port Phillip.

Obs.—We forwarded specimens to Mr. Suter, New Zealand, who remarks: "I take it to be *R. subfusca*, Hutton; it is a little smaller than the type, and the spire a trifle more convex, but I have similar examples from Cook Strait."

RISSOA LIDDELLIANA, Hedley.

1907. Rissoa liddelliana, Hedley. P.L.S. N.S.W., vol. xxxii. p. 494, pl. 17, f. 24.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Mr. Hedley has kindly compared our specimens with the type and remarks that they "are larger and comparatively broader."

THALOTIA WOODSIANA, Angas.

1872. Thalotia woodsiana, Angas. P.Z.S. Lond., pl. 42, f. 4, 5.

Hab.—Portland Bay (Angas).

Obs.—Size of Type: 8 x 5 lines. We have not seen this species.

CALLIOSTOMA ZIETZI, Verco.

1905. Calliostoma zietzi, Verco. T.R.S. S.A., vol. xxix., p. 166, pl. 31, f. 1-3.

Hab.—Dredged, about six fathoms, between Phillip and French Islands, Western Port.

Obs.—Size of Type: Height, 8; diameter of base, 5 mm.

SCISSURELLA AUSTRALIS, Hedley.

1903. Scissurella australis, Hedley. Mem. Aust. Mus., vol. iv., p. 329 and 330, Fig. 63 in text.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Height, 2.5 mm.; major diameter, 3 mm. Our specimens have been identified by the author, but the sculpture on ours is not so strong.

EMARGINULA SUPERBA, Hedley and Petterd.

1906. Emarginula superba, Hedley and Petterd. Rec. Aust. Mus., vol. vi., p. 216, pl. 37, f. 7, 8.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—The size of the type is: Length, 24; breadth, 18; height, 9 mm. Our specimen is much smaller. This species much resembles *E. dilecta*, A. Ad., but differs from it in having a much incurved and overhanging apex.

ACANTHOCHITES MAUGHANI, Torr and Ashby.

1898. Acanthochites maughani, Torr and Ashby. T.R.S. S.A., p. 218, pl. 7, f. 5.

Hab.—Shoreham, Western Port.

Obs.—Size of Type: Length, 8; breadth, 4 mm.—dried specimen. One of us also recently obtained a small living specimen at Freshwater Bay, N.S.W.

SAXICAVA SUBALATA, Gatliff and Gabriel.

1910. Saxicava subalata, Gatliff and Gabriel. Ante page. 85.

THRACIOPSIS ARENOSA, Hedley.

1904. Thraciopsis arenosa, Hedley. P.L.S. N.S.W., vol. xxix., p. 197, pl. 9, f. 26, 27.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Obs.—Size of Type: Height, 2.9; length, 4.55 mm

Genus **Cuspidaria**, Nardo, 1840.

CUSPIDARIA TASMANICA, T. Woods.

1876. Neaera tasmanica, T. Woods. P.R.S. Tas., for 1875, p. 27.

1897. Cuspidaria tasmanica, Tate. T.R.S. S.A., vol. xxi., p. 44.

1901. Cuspidaria tasmanica, Hedley. P.L.S. N.S.W., vol. xxvi., p. 21, f. 20. In text.

1901. Cuspidaria tasmanica, Tate and May. Id. p. 421.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

KELLIA ANGASIANA, Tate.

1887. Kellia angasiana, Tate. T.R.S. S.A., vol. ix., p. 68, pl. 5, f. 7.

Hab.—San Remo (Thos. Worcester).

Obs.—Size of Type: Antero-posterior diameter, 2.5; umbo-ventral diameter, 2 mm. A triangularly oval, thin, dull white, semi-transparent shell.

LEPTON OVATUM, Tate.

1887. Lepton ovatum, Tate, T.R.S. S.A., vol. ix. p. 68, pl. 5, f. 11.

Hab.—Portsea, Port Phillip.

Obs.—Size of Type: Antero-posterior diameter, 2; umbo-ventral diameter, 1.5 mm.

Crassatellites micra, Verco.

1895. Crassatella micra, Verco. T.R.S. S.A., p. 93, pl. 1, f. 3.

1907. Crasatellites micra, Verco. Id. vol. xxxi., p. 313.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Condylocardia porrecta, Hedley.

1906. Condylocardia porrecta, Hedley. P.L.S. N.S.W., vol. xxxi., p. 475, pl. 38, f. 24.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Glycimeris tenuicostata, Reeve.

1843. Pectunculus tenuicostatus, Reeve, P.Z.S. Lond., p. 80.

1843. Pectunculus tenuicostatus, Reeve. Conch. Icon., vol. i., pl. 6, f. 35.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Glycimeris sordidus, Tate.

1891. Pectunculus sordidus, Tate. T.R.S. S.A., vol. xiv., p. 264, pl. 11, f. 8.

1907. Glycimeris sordidus, Verco. Id. vol. xxxi., p. 227.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

Genus Arcoperna, Conrad, 1865.

Arcoperna scapha, Verco.

1908. Arcoperna scapha, Verco. T.R.S. S.A., vol. xxxii., p. 196, pl. 12, f. 1-5.

Hab.—Off Wilson's Promontory, Commonwealth Trawler "Endeavour."

CHLAMYS RADIATUS, Hutton.

1873. Pecten radiatus, Hutton. Cat. N.Z. Moll., p. 82.
1880. Pecten radiatus, Hutton. Man. N.Z. Moll., p. 171.
1908. Chlamys radiatus, Hedley. P.L.S. N.S.W., vol. xxxiii., p. 472, pl. 10, f. 28.

Hab.—Ocean Beach, Point Nepean; Torquay; off Wilson's Promontory, Trawler "Endeavour."

Obs.—Mr. Henry Suter, of New Zealand, has kindly identified specimens submitted to him as being young shells of the above-named species, The size of the type is: Height, 1.8; breadth, 1.7 inch. The largest examples we have hitherto obtained are: Height, 0.60; breadth, 0.56 inch.

In part 8 of the Catalogue by Pritchard and Gatliff, *Chlamys hedleyi*, Dautzenburg, was recorded, upon the identification of Mr. C. Hedley. He now informs us he was mistaken, and further states that *C. hedleyi* falls in as a synonym of *C. undulatus*, Sowerby. The shell he wrongly identified we now find to be *C. radiatus*, Hutton.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910].

Art. XVI.—*Note on a Supposed Nematode Parasitic in the Circular Muscle of an Earthworm. (Diporochaeta grandis).*

By GWYNNETH BUCHANAN, M.Sc.,

Government Research Scholar in the Biological Laboratory, University of Melbourne.

(With Plates XX., XXI.)

[Read 14th July, 1910.]

While examining some specimens of the earthworm *Diporochaeta grandis*[1] from Endeavour River, Queensland, I was struck by the appearance of some curious yellow patches scattered at irregular intervals over the external surface of certain individuals. These patches measure about 3 mm. by 1 mm., and are slightly raised.

On opening several under the dissecting microscope, they were found to contain a mass of structureless yellow material, embedded in which was a single thread-like form, in many cases much coiled. On clearing the contents of the patches in carbolised absolute (for the use of which and for valuable advice I am indebted to Dr. G. Sweet), I found on examination two distinct sets of thread-like forms closely resembling nematodes in general appearance.

The first (Fig. 1) had the ordinary truncated end of a nematode, with a faint indication of a pharynx leading to an alimentary canal, apparently ending abruptly in front of the sharply recurved posterior end.

The second (Fig. 2) was definitely pointed at each end, with no apparent pharynx. None of the specimens were straight, so that it was hard to obtain accurate measurements. The

1 Spencer, "Further Descriptions of Australian Earthworms, Pt. I." Proc. Roy. Soc. Victoria, vol. xiii. (1900), p. 63.

length of the first form, as nearly as could be computed, was 3.9 mm.; that of the second, 3.6 mm; while the breadth of both was .18 mm.

I cut sections of the body wall of the earthworm in the region of one of these patches, staining them with acetic acid alum carmine, and in some cases double staining with eosin. These sections showed a distinct fibrous capsule in the circular muscle of the body wall of the host (Fig. 3, c). Inside this the body of the parasite was cut across and surrounded by more or less of the structureless substance before mentioned, which was usually rather deeply pigmented (Fig. 3, p). This substance would seem to be either excrete material from the parasite itself, or, rather, the disintegrated material of the body wall of the host, as no cellular arrangement was made visible by any method of treatment. The body of the parasite itself had a very nematode-like appearance, but even under the low power it was clear that its internal structure was not well preserved—a fact which was probably due to the presence of cuticle, since the tissues of the host were in very good condition. Practically the whole of the internal cavity seemed filled with long clear cells, which were apparently attached to the alimentary canal at their inner end. Under a high power, however (4 eyepiece, 7 obj., Fig. 4), these cells were found to be lying loose in the body cavity attached at their outer end to some inward projections of the apparently structureless body wall. This body cavity was divided fairly distinctly into two halves, and each of these much less distinctly also into two. In all four quarters were ten inward projections, but the attached cells had none of the characteristic striations of nematodes. The only indication of the lateral line was very indistinct. From it the clearest mesenteries (Fig. 4, mes.) pass to the alimentary canal, along the whole length of which run two structureless lines which stain homogeneously with eosin, in much the same way as the body-wall, and, occasionally spread almost round the alimentary canal. The cells of the latter are very definite, and are regularly arranged with their nuclei towards the inner cavity (Fig. 4, al.c). At one end is a curious structure apparently arranged around the alimentary canal. (Fig. 5.) On the outside is the homogeneously staining mass

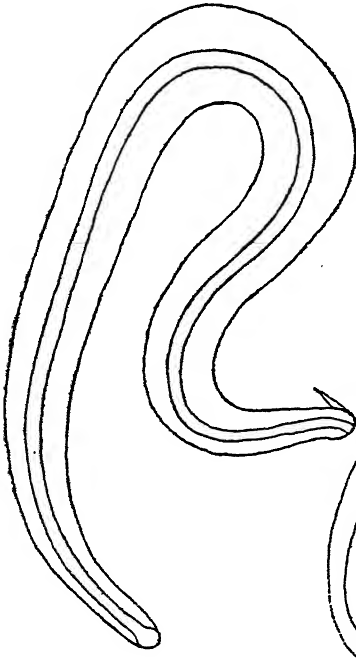


Fig 1

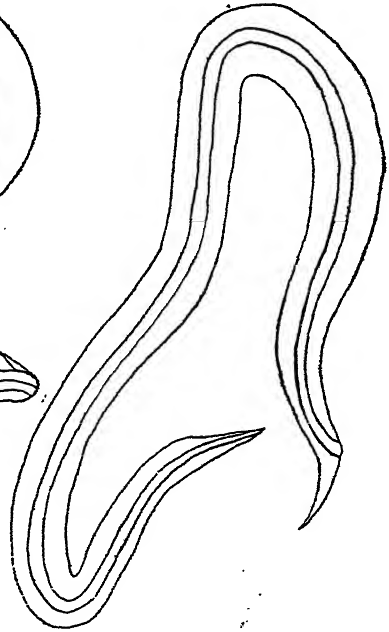
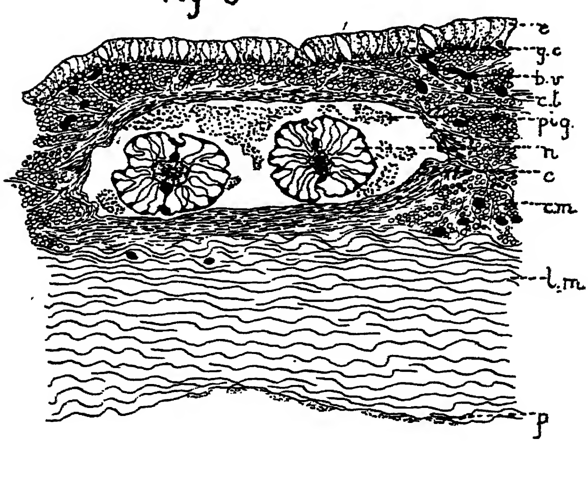


Fig 2

Fig 3



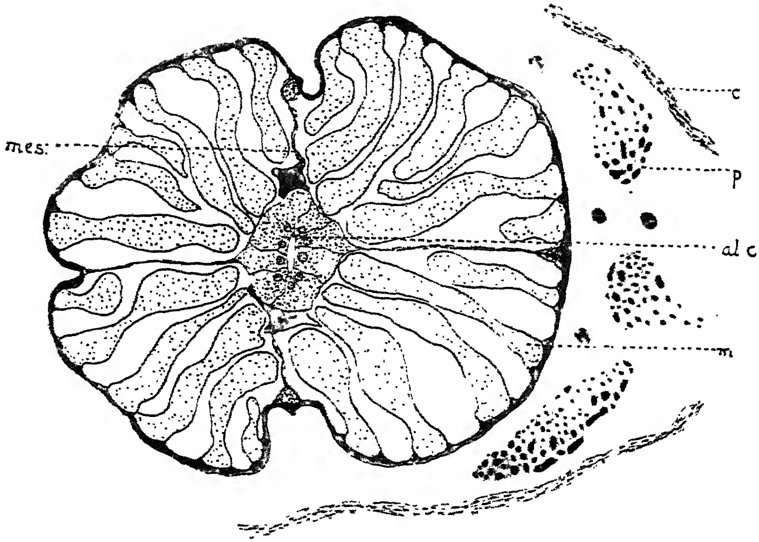


Fig. 4

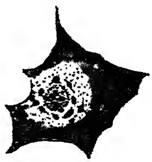


Fig 5

forming a complete ring instead of being confined to two rows. It encloses in a thick layer a granular structure containing branched cells closely resembling nerve cells. At about the middle of its length cells begin to appear in the centre of this structure, which seem to be continuous with those of the alimentary canal.

It will be seen from the foregoing description that in many features this parasite resembles a nematode; the entire absence of reproductive structures, however, makes it impossible to attempt a classification. Dr. Sweet has suggested that it may be a larval form, in which case it may be a stage in the life history of some already recognised species.

EXPLANATION OF PLATES XX., XXI.

Figs. 1 and 2.—Whole specimens of two kinds of parasite.
„ 3.—Low power drawing of the general position of the parasite in the body wall of the host.
„ 4.—High power drawing of a transverse section of the parasite.
„ 5.—(?) Nervous structure at one end of the parasite. High power.

Figs. 1, 2 and 3 outlined with camera lucida and Leitz 3 objective, 2 eyepiece.

REFERENCE LETTERS.

al. c.—Alimentary canal.
b. v.—Blood vessel.
c. —Capsule.
c m.—Circular muscle.
e. —Epidermis of host.
g. c. —Goblet cell.
l. m.—Longitudinal muscle.
p. —Peritoneal membrane.
pig. —Pigment inside capsule.
m. —Muscle cell of parasite.
mes. —Mesentery of parasite.
a. —Parasite.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910].

Art. XVII.—*Note on the Existence of Spirochaetosis affecting Fowls in Victoria.*

By J. A. GILRUTH, D.V.Sc., M.R.C.V.S., F.R.S.E.

(Professor of Veterinary Pathology in the University of Melbourne).

[Read 3rd March, 1910].

The Fowl Tick (*Argas*) has been recognised as an exceedingly troublesome skin parasite of the domesticated fowl in certain parts of the northern districts of Victoria for a number of years past, and its association with a febrile condition, especially in young birds during the summer months, has, it would appear, been commonly observed, although, as far as I can gather, beyond some short paragraphs in the daily press (until the last month, when an article by Dr. A. A. Brown appeared in the "Journal of Agriculture"), no definite scientific observations have been placed on record. This is rather surprising in view of the fact that the Department of Agriculture, I am informed, has for some years been endeavouring to prevent the spread of the tick to other districts.

Soon after my arrival in Melbourne, at the commencement of last year, I was informed of the existence of the so-called "tick-fever" in certain districts. Seeing that since 1903, when Marchoux and Salimbini first described the presence of a spirochaete in the blood of Brazilian fowls affected with the tick *Argas*, other observers in India, Sudan, Rhodesia, Bulgaria and elsewhere have also demonstrated the connection between the two parasites, I was naturally anxious to ascertain if in Australia, along with the tick as a skin parasite, the spirochaete was also associated with a blood parasite. I found it, however, impossible to secure a tick-infected fowl during the past summer.

Since then, Dr. S. Dodd, Chief Veterinary Officer and Bacteriologist to the Queensland Government, in his last annual report, describes fully the disease Spirochaetosis as affecting

fowls in that State, and has demonstrated its transmission by the common fowl-tick, *Argas persicus*.

Through Dr. Brown, of the Agricultural Department, at the request of the Minister for Agriculture, I received on 22nd January a live fowl presenting the following definite symptoms: —General dejection, somnolence, ruffled feathers, pale comb, slight diarrhœa and loss of appetite. Only four ecto-parasites were to be found on the skin, these being apparently all larval forms of a parasite of the Argas type, and were handed to Dr. G. Sweet for identification. These Dr. Sweet has described in this volume as belonging to a new species, *A. victoriensis*.

Examination of blood smears made in the usual way fixed in alcohol and stained with Giemsa's stain, gentian violet, etc., demonstrated considerable numbers of the characteristic spirochaetae as described by Marchoux, Laveran and others. There was also a marked increase in the nmber of eosinophile white blood corpuscles.

The spirochaetae increased in number till the time of death 56 hours after arrival. Post-mortem examination did not disclose any decided pathological change, and the spleen was not enlarged.

Enquiry from Dr. Brown elicited the information that the bird had been sent from a non-infected to an infected district, and there exposed to the ticks only six days prior to being forwarded to me, which indicates the rapidity of the infection.

A live fowl was inoculated subcutaneously with five drops of blood from the heart of the first fowl, a few minutes after death. No swelling developed at the seat of inoculation. Spirochaetes were found in the peripheral blood on the third day, but only in one to every twenty fields of the microscope. On the fourth and fifth days the numbers increased greatly, and several could be seen in each field. On the sixth day, however, extremely few could be detected, while subsequently none could be seen. The animal remained in apparent health. The disappearance occurred without any preliminary clumping, and no intra-corpuscular bodies of Balfour's "after phase" could ever be determined. It should be also noted that careful examination of smears from various parts of the naturally affected fowl, which died at the laboratory, failed to reveal any bodies within

the red corpuscles, as described by Dr. A. A. Brown in the "Journal of Agriculture" for February.

Intracorpuscular forms of spirochaetes have been described by Balfour[1] as constituting the "after phase" of spirochaetosis. These bodies were only found in animals which recovered, and he regards them as a definite stage in the life history of the blood parasite. Von Prowazek has recorded somewhat similar intracorpuscular bodies in fowl Spirochaetosis. Dodd, however, in his Queensland experiments failed to demonstrate such bodies in any of the recovered fowls. My examination of the blood in which the spirochaetes disappeared so suddenly also failed to detect any similar bodies to those described by Balfour.

1 3rd Report. Wellcome Research Laboratory, Sudan.

[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. I., 1910].

ART. XVIII.—*Spirochaetae in Lesions affecting the Pig.*

BY J. A. GILRUTH, D.V.Sc., M.R.C.V.S., F.R.S.E.

(Professor of Veterinary Pathology in the University of Melbourne)

[Read 14th July, 1910.

The presence of these protozoan parasites has been already described in certain pathological conditions of the pig, notably by Dodd, as occurring in an ulcerative skin disease in the Transvaal, transmissible both by contagion and by inoculation,[1] and by Cleland in "Castration tumours" of the pig in West Australia.[2] Recently the occurrence of spirochaetes has been observed by me in several lesions of somewhat diverse character in Victorian pigs, of which the following is a short description.

SKIN AND SUBCUTANEOUS LESIONS.

In January, 1910, a pig's head was received from the Veterinary Department of the Victorian Government. It was affected with a large ulcerating tumour the size of a fist on the side of the cheek. The tumour was dense, and had the characteristics of a fibroma. Unfortunately, no preservative having been used, putrefaction was somewhat advanced. Microscopical examination showed throughout the structure of the tumour numerous spirochaetes, the majority similar in size to those found in the fowl, but a number were much shorter than those usually found in avian blood.

As the owner stated that he had previously had three pigs similarly affected and still had one showing a similar condition, Dr. Cameron requested him to forward it alive. It was duly sent, but unfortunately arrived during my absence on a holiday. On arrival it was observed to be suffering from a hard swelling on the side of the left jaw, and a healthy young pig was placed in the same pen to test the possibility of contagion.

On my return to Melbourne it was found that the swelling on the left jaw had disappeared, but that the left knee was swollen,

1 Jour. Comp. Path., 1906.

2 Parasitology, vol. i., No. 3).

and showed a small ulcerating surface just under the joint. Below this swelling was a caseous and necrotic area, extending downwards about two inches, and surrounded with chronic inflammatory tissue. Smears from this showed numerous spirochaetes and a mixed bacterial flora.

Attempts to transfer the condition by inoculation on scarified skin resulted in a number of granulomatous, inflammatory, chancroid lesions being slowly developed at and in the vicinity of the scarified area. These ultimately disappeared, but at no time were spirochaetes detected, although microscopical examinations were frequently made: the granulomatous tissue appeared to be due simply to streptococci, which were present in large numbers.

The contact pig remained normal.

Recently I have had an opportunity of examining two cases of scrotal tumours similar to those described by Dr. Cleland, through the courtesy of Mr. John Robertson, Director of the City Abattoir. Both pigs were in fat condition, about 18 months old, and I was informed the viscera of each were normal. At first glance the tumours had almost the appearance of normal testicles somewhat enlarged, being very prominently situated in the scrotal region subcutaneously. The skin was normal, but for the scar where the wounds by the castration knife had been made. In one case a tumour was situated in each scrotal sac, but in the other only one was present. On dissection the tumours, which were ovoid, slightly flattened and of the diameter of a large orange, were found to be circumscribed and fairly dense in consistency. On section the new growths were seen to be composed of fibrous but oedematous, new connective tissue, enclosing a central, irregular, necrotic, caseous area almost the size of a walnut, immediately around which the fibrous tissue was distinctly of a greyish dirty colour, strongly contrasting with the translucent homogeneous appearance of the peripheral mass.

In each case the spermatic cords, at the distal end of which the tumours proper were situated, were thickened, being about an inch in diameter, and contained several circumscribed caseous areas varying from the size of a marble to that of a walnut.

Microscopical examination of smears of the central degenerated material from the terminal tumours showed many spirochaetes similar to those already described, along with masses of various kinds of micro-organisms, such as cocci, long and short bacilli. Scrapings from the oedematous fibrous tissue showed also many spirochaetes with numbers of bacteria though few in comparison with those present in the caseous centre. The caseous nodules in the thickened cord, while containing many mixed bacteria, appeared to be free of spirochaetes.

As to whether the spirochaetes were the cause of the new fibrous growths under consideration is a question that requires further investigation, but the indications at least are that their presence conduces to the formation of the new fibrous issue observed, while the central degeneration is probably the result of the bacterial invasion.

Sub-mucous Cysts of Large Intestine.

Spirochaetes have been found by me recently associated with intestinal lesions of the pig, but apparently they were not the cause of any serious general disturbance.

The lesions were first observed in two young pigs received alive from the country for examination. The animals on arrival were very lean, and though the temperatures were above normal the appetite was good. The blood of each was normal so far as erythrocytes were concerned (7,500,000 to 8,000,000), but there was a definite increase in leucocytes (50,000) chiefly eosinophiles.

During the succeeding three days, as the condition was rapidly improving and no definite symptoms could be detected beyond a slight fluctuation in the temperature, one was slaughtered for examination, and the other a week later, when it was obvious a very decided improvement in appearance had taken place, these facts alone pointing to some neglect or dietetic error having been the cause of the poor condition.

The first pig killed showed a definite pathological condition of the large intestine. The mucosa of the caecum was affected for an area of about eight inches with patches of inflammation covered by diphtheritic false membrane. The large intestine

throughout its whole course showed numerous circular, flattened, greyish nodules, each about the size of a small pea, there being about 2 to 4 present to the square inch. These nodules were distinctly observable without incising the bowel, and caused some projection of the serous covering. On examination of the mucous surface slight circular elevations were observed corresponding to these nodules, the majority showing a minute central depression, through which the contents could be readily squeezed. These nodules were apparently cystic in nature; in some instances the contents appeared translucent, jelly-like and not readily broken down, with a small greyish caseous centre, in others the contents were completely caseous.

On microscopical examination the material was seen to consist chiefly of fibrinous debris with pus cells and some columnar epithelia. A peculiar feature of the less degenerated contents was the presence in smears of a finely laminated membranous structure as if part of a parasitic cyst wall. Stained by Giemsa's method myriads of beaded bacteria of varying length, cocci and bacilli could be detected, but, in addition, especially in the "laminated" membrane, could be seen many delicate spiral organisms with all the characters of spirochaetae. These were so regular and so numerous in the "laminated" structure, which was comparatively free of bacteria, that there seemed to be some decided connection. It should be observed that in the fresh state no definite movement of the spirochaetes could be observed, and that there were always some actively motile cercomonas found present.

Sections of the intestinal wall demonstrate these nodules to be of the nature of small cysts of the deeper glands, external to the muscularis mucosae and apparently all these glands are more or less affected. Considerable irritation is evidenced by the accumulation of lymphocytes and some formation of new fibrous tissue with atrophy of the muscular wall, at the periphery, while the centre is composed of fibrinous material with shed epithelial cells and more or less degenerated polymorphs. Masses of bacteria, chiefly bacilli, showing great irregularity in staining, can be seen present amongst the cells and debris.

It may be noted that a young pig about six weeks old which was placed in the same pen as these pigs developed a high tem-

perature with capricous appetite, ten days later, and was killed on the fourteenth day as it was evidently recovering from this condition. Post-mortem examination disclosed a broncho-pneumonia with irregular areas of degeneration (caseous) which was evidently the cause of the indisposition. In addition, however, on examination of the mucous membrane of the large intestine a number of nodules similar but smaller in size to those above described were observed. They were not visible on the serous surface and none were degenerated; all showed the central depression, and containel a gelatinous material, amongst which bacteria as before, and a few cercomonas could be demonstrated, but no spirochaetae.

That these nodules were not induced by contagion from the previous cases was proved by the fact that a control from the same litter which had remained in good health, killed ten days later, was also affected with similar nodules. These again contained no spirochaetes, but many bacilli and a few cercomonas.

It may be assumed therefore that whatever may be the pathological significance (obviously not great) of these nodules or cysts, which were probably due to the bacterial invasion, the presence of spirochaetes within their contents was probably accidental.

In neither of the first two pigs were any metazoan parasites observed though careful search was made throughout the whole of the intestinal tract. It may therefore be concluded that the definite eosinophilia present in each was probably due to the spirochaete invasion of the intestinal cysts described.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. I., 1910.]

Art. XIX.—*Contributions to the Flora of Australia, No. 15.*[1]

By ALFRED J. EWART, D.Sc., Ph.D., F.L.S.
(Government Botanist and Professor of Botany in the Melbourne University);

JEAN WHITE, D.Sc.,

and

BERTHA REES
(Government Research Scholars).

(With Plates XXII-XXIV.).

[Read 14th July, 1910.]

Atriplex pterocarpa, Ewart and Rees, n. sp. (Chenopodiaceae)

Near Silverton, New South Wales. E. N. Charsley, 1886.

Apparently a shrub, the stem and leaves bearing short, woolly hairs, which give the plant a whitish appearance. Leaves ovate to lanceolate, ovate leaves with fairly long petioles, and lanceolate leaves narrowed at the base with short petioles—entire or with margins slightly indented.

Flowers unisexual in globular axillary clusters 2-4 lines in diameter. The upper clusters consist of male flowers surrounded by a few female, the lower clusters of female only. Female flowers—perianth in 2 segments, with irregularly serrated edges, and closely covered on the outside with short woolly hairs, on the inner side of the segments is a peculiar outgrowth of finely branched greenish veins. Styles 2 united at extreme base—Male flowers—perianth in 4 segments, 4 stamens opposite to the segments of the perianth. Fruiting perianth compressed, entirely closed except at apex, ovate orbicular, about ½ inch across, margin entire. Valves thin at the edges, but

1 No. 14 in Proc. Roy. Soc. Victoria, vol. xxiii., pt. i., n.s. (1910), p. 54.

slightly roughened and thickened towards the centre and closely set with much branched veins which are specially conspicuous on the inner side of the valves. Radicle lateral.

BABIANA STRICTA, Ker-Gawl (B. VILLOSA, Ker-Gawl). (Irideae). "Upright Babiana."

Germantown, near Geelong, Victoria, H. B. Williamson, Nov., 1909.

A native of South Africa, apparently not sufficiently established to be considered naturalised. The plant has the perianth tube shorter than usual, the flowers being apparently not quite fully developed.

GASTROLOBIUM LAYTONI, J. White, n. sp., after Captain Layton. (Leguminosae).

Watheroo Rabbit fence, Max Koch, 1905, No. 1337.

An erect shrub of 1.5 to 2.5 feet high. Branches stiff, when young covered with short greyish hairs, the older branches only slightly so. Leaves petiolate, laminae 1.5-2 inches in length, and $\frac{1}{2}$-$\frac{3}{4}$ inch in breadth, petiole about 1.5 lines long. Leaves cuneate, blunt or sometimes very slightly convex at the apex, with entire margins, which are hardly recurved, and tend to be folded inwards, venation rather prominent on the upper surface, which is almost glabrous, the under surface being covered with felt-like greyish hairs, opposite, stipules filamentous; about 1 line long.

Racemes axillary, rachis 1.5-2.5 inches covered with minute greyish hairs, pedicels distinct, hairy, under 1 line in length. Bracts and bracteoles deciduous.

Flowers small, calyx rather thickly pubescent, the 2 upper lobes united a little higher up than the others, 1.5-2 lines long. Vexillum less than twice as long as the calyx, and a little longer than the alae or carina, about 2 lines in breadth.

Stamens free, ovary densely covered with white wooly hairs, stipes $\frac{3}{4}$-1 line in length.

The plant belongs to the Series II. (Racemosae) of Bentham.

It seems to be nearest to *G. polystachyum*, Meissner. It is easily distinguished externally from that species by the leaves not being undulate and the racemes not sessile.

HIBBERTIA MILLARI, F. M. Bailey. (Dilleniaceae).

This Queensland plant is distinguished from *Hibbertia angustifolia*, Benth. (*Hibbertia Benthami*, F.v.M.) (*Hemistemma angustifolia*, R.Br.), as being "of more robust habit, with fewer and larger flowers in the spike, and without the prominent rusty-red midrib of the leaf of that species." An original specimen of R. Brown's is quite as robust, and the red midrib is quite as prominent in one of Bailey's specimens as in some of *H. angustifolia*. If the description of the latter were amended so as to read "leaves with a more or less prominent rusty-red midrib, flowers in clusters of 1 to 5 (instead of 2 to 5), sepals about 4 lines long (instead of 3 lines)," this would include the present plant and avoid the necessity for the creation of a new species or variety.

The plant given in the Recording Census of the Victorian Flora as *H. angustifolia* should be *H. procumbens*, D.C., the *H. Benthami* of F. v. Mueller reverting to the name of *H. angustifolia*, Benth.

HIBISCUS TRIONUM, L. (Malvaceae). "Bladder Hibiscus."

Coode Island, J. R. Tovey and C. French Jr., Oct., 1908.

Only previously recorded as a naturalised alien from the North-Western district.

LEPTOSPERMUM SCOPARIUM, Forst., var. ROTUNDIFOLIA, Maiden and Betche. (Myrtaceae).

(Proceedings of the Linnean Society of New South Wales, 1900, Vol. XXV., page 101.)

The authors were doubtful as to whether this plant belonged to *L. flavescens* or *L. scoparium*. It is undoubtedly nearest to the *var. grandiflorum* (*L. grandiflorum*, Lodd) of *L. flavescens*, and specimens of the same plant were labelled *L. grandiflorum*,

Lodd, *var. rotundifolia* by Mueller. It is questionable whether this variety is not worthy of specific rank (larger flowers, broader leaves, usually larger fruits). It certainly includes several subforms of which Mueller's and Maiden and Betche's variety is one, and with it might be included some broad-leaved forms of *L. scoparium*, which have distinct pungent points. The distinction between the three species would not be any more artificial than that already existing between *L. flavescens* and *L. scoparium.*

Prasophyllum brachystachyum, Lindl. (Orchidaceae).

Sub-Alpine Eucalypt forests. County Talbot, Victoria. F. M. Reader, 20/6/09, 4/7/09, and June, 1910.

The form of the lateral appendages in these specimens did not appear to tally with the description in Bentham's "Flora Australiensis," and it was only after examining the type specimen sent from the Herbarium at Kew, that we were able to discover the correct species.

For this reason, we make the following amendment to Bentham's description:—" lateral appendages of the column bifid or unequally 2 lobed, both lobes acuminate, outer being slightly larger and broader than the inner." New to Victoria, only previously recorded from Tasmania.

Prasophyllum despectans, Hook., f., var. intermedia, Ewart and Rees, n. var.

Warrandyte, Upper Yarra, Victoria.

Sent by C. Walter, 9/8/96.

These specimens are very similar in structure to *P. despectans*, though they differ in appearance, drying a much lighter colour than the type specimen from which it also differs in size, being slightly larger. The main difference is in the form of the lateral appendages of the column, which are either unequally 2 dentate, the inner lobe being much smaller or entire with a small tooth-like projection along the inner margin.

PULTENAEA ADUNCA, Turcz. (Leguminosae).

Twenty-five miles North-West of Port Lincoln, South Australia, E. H. D. Griffith, 10/10/09, only previously recorded from West Australia.

The specimen has the leaf obtuse. It may also be hooked at the tip. Calyx, bracteoles, ovary, corolla agree with the type. The style is, however, not specially thick or hooked. This may be an error in Bentham's description.

TOLPIS UMBELLATA, Bert. (Compositae).

Geelong, Victoria, December, 1909, and February, 1910, H. B. Williamson.

This plant is close to *T. barbata*, Gaertn. It differs in having few or no stem leaves, oblong-linear instead of lanceolate leaves, shorter involucral bracts and usually smaller and narrower ligulate corollas. The fruit and pappus are practically identical in both. In Moore's "Handbook to the Flora of New South Wales," page 425, *Tolpis barbata*, Gaertn, is recorded as an escape from cultivation. Three New South Wales specimens in the Herbarium, however (Berrima; Richmond, Wools; and Parramatta, L. Atkinson) all prove to be *T. umbellata*.

In Victoria, the plant is hardly common or well enough established to be considered a naturalised alien as yet.

VERONICA SALICIFOLIA x V. SPECIOSA (V. ANDERSONII, Hort.). (Scrophulariaceae).

P. R. St. John, Hanging Rock, Woodend, Victoria, Feb., 1910.

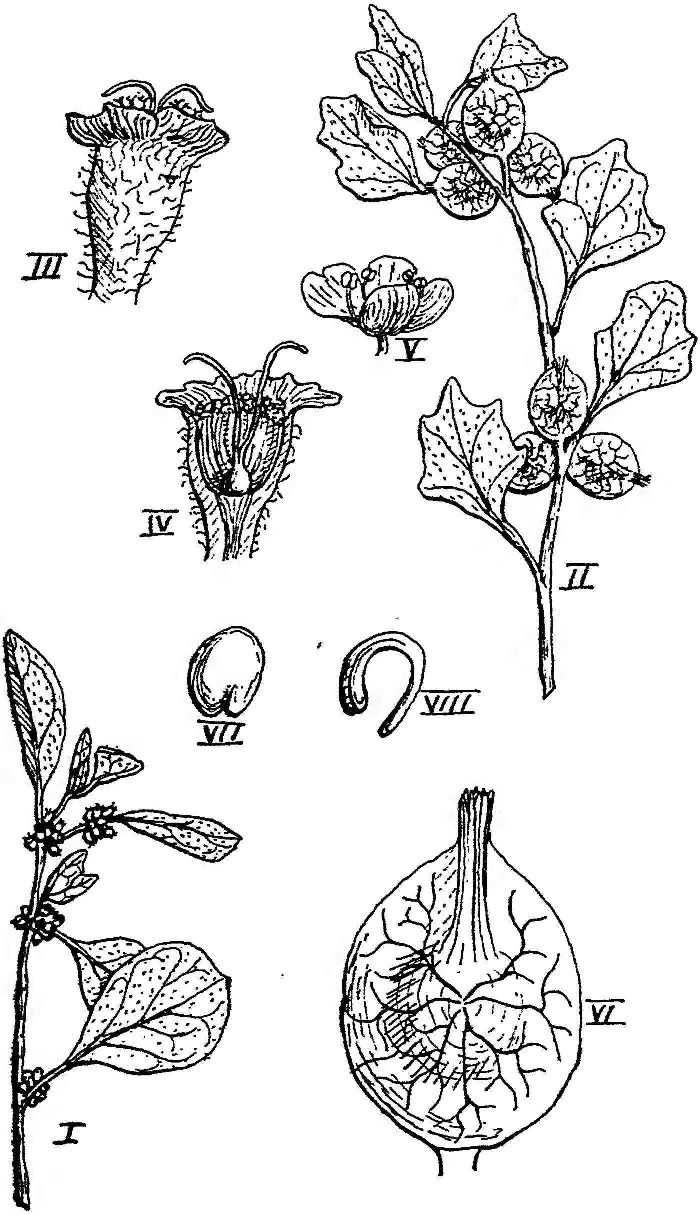
This hybrid, often grown in gardens under the name of *V. Andersonii*, was found growing apparently wild, but has evidently been planted accidentally or purposefully, and can therefore only be classed as a garden escape.

EXPLANATION OF PLATES XXII.-XXIV.

PLATE XXI.—*Atriplex pterocarpa*, Ewart and Rees.

Fig. 1.—Branch bearing axillary inflorescences.

„ 2.—Fruiting branch.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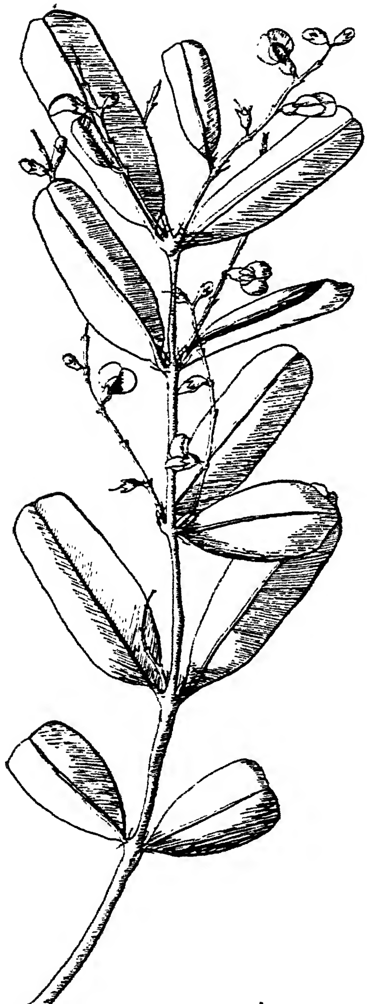

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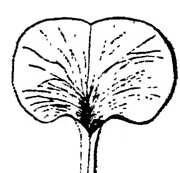

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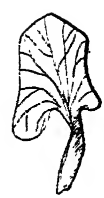

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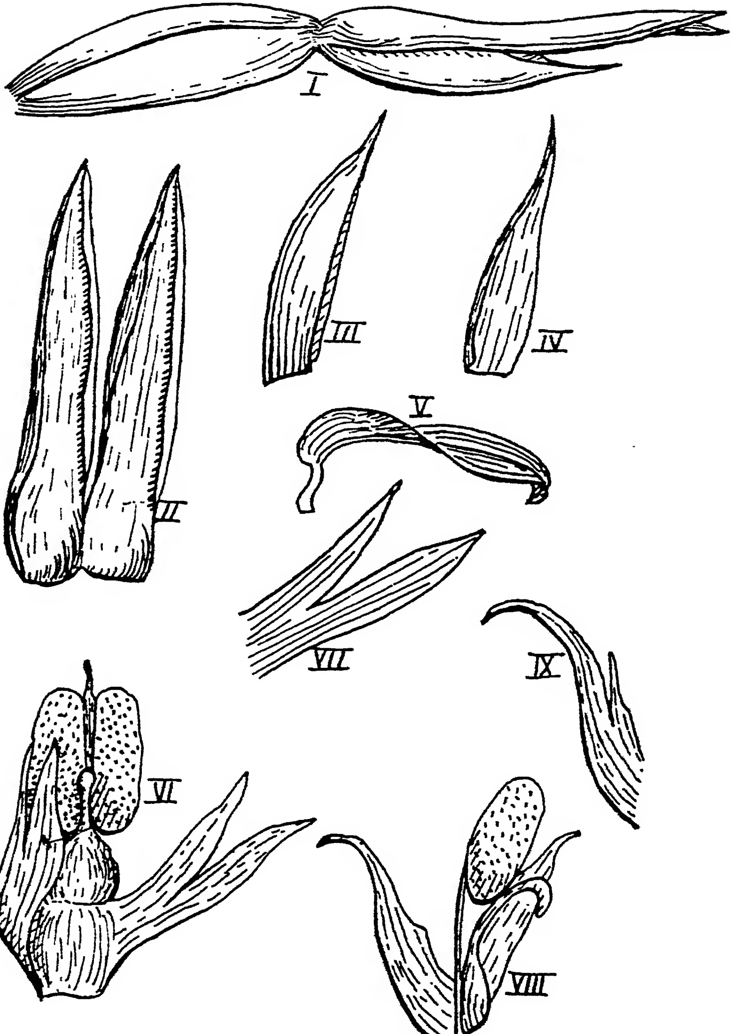
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Fig. 3.—Single female flower (enlarged).
„ 4. Section of female flower (enlarged).
„ 5.—Single male flower (enlarged).
„ 6.—Single fruit (enlarged).
„ 7.—Seed.
„ 8.—Embryo.

PLATE XXII.—*Gastrolobium Laytoni*, J. White.

Fig. 1,—Flowering branch (natural size).
„ 2.—Vexillum (enlarged).
„ 3.—Ala (enlarged).
„ 4.—Carina (enlarged).
„ 5.—Part of calyx cut away to show the gynaecium.

PLATE XXIII.—*Prasophyllum brachystachyum and P. despectans.*

Fig. 1.—Single flower of Prasophyllum brachystachyum.
„ 2.—Lateral sepals of P. brachystachyum.
„ 3.—Dorsal sepal of P. brachystachyum.
„ 4.—Lateral petal of P. brachystachyum.
„ 5.—Labellum of P. brachystachyum.
„ 6.—Column of Reader's specimen, one appendage turned back.
„ 7.—Lateral appendage of type specimen from Kew.
„ 8.—Side view of column of P. despectans var. intermedia.
„ 9.—Second type of appendage in P. despectans var. intermedia.

[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. I., 1910.]

ART. XX.—*Australian and Tasmanian Coleoptera Inhabiting or Resorting to the Nests of Ants, Bees, and Termites.*

BY ARTHUR M. LEA.

(With Plates XXV.-XXVII.).

[Read 14th July, 1910].

For about twenty years, whenever the opportunity presented itself, I have examined the nests of ants, bees, and termites, in which, as is well known, many remarkable forms of insect life are to be found. Many species have been recorded from such nests by past and present workers at Australian beetles, but no paper dealing with them as a whole has hitherto been published. In 1904, however, I had the privilege of offering to this Society a short paper dealing with some ants'-nest beetles, including two very curious new genera, that were taken in the Mallee by Mr. J. C. Goudie. Since then Mr. Goudie has taken other curious forms, and Messrs. H. W. Davey of Geelong, H. W. Cox and Dr. E. W. Ferguson of Sydney, have sent many species from ants' nests, and at various times a few others were received from Messrs. C. French of Melbourne, George Masters, H. J. Carter, W. W. Froggatt and Taylor Bros. of Sydney, H. H. D. Griffith of Adelaide, H. Elgner of Cape York, H. Hacker of Cairns, Mrs. F. H. Hobler of Toowoomba, and Mr. Aug. Simson of Launceston. A few also were received from the Australian Museum that were taken by the late Rev. R. L. King. As the total number of species now known to me is very considerable, it was thought advisable to prepare a paper dealing with them, but including in it all the species hitherto recorded as having been taken in the nests of ants, bees and termites in Australia. It is hoped also that papers dealing with species of other orders of insects found in ants' nests will be published shortly, as materials for such have been accumulating for some time, and several specialists have been requested to deal with them.

As instancing the abundance that insects sometimes occur with ants, the following extracts from Mr. Davey's letters should be of interest:—

"It came on to heavy rain as soon as I arrived at Ocean Grove, but I made for some good, old-established nests of Irids (*Iridomyrmex nitidus*) among cranberries, and shook a few handfuls, ants and all, into a small bag, and went through this. The debris yielded 16 *Staphylinidae* (*Dabra termitophila* var. *victoriensis*, *D. myrmecophila*, a minute *Homalota* and a minute *Hymenopteron*[1]), 60 *Nepharis* (*N. costata*), 16 *Pselaphidae* (*Articerus cylindricornis* and *Euplectops gibbosus*), 2 *Anthicidae* (*Anthicus australis*), 2 Curculios (*Achopera lachrymosa*, and a minute species of *Erirhinides*[2]), 1 larva (of ?), 1 *Oligotoma* (also in the larval form), and Acarids. The cranberry was badly infested with scale insects, and the ants roof these over, and I always thought would prove good collecting. One great advantage is no waste of time—just bag them and go through them at night. The disadvantage is the swarms of ants you have to bag." Later Mr. Davey wrote:—"The name of the cranberry is *Styphelia humifusa*, and I have seen plenty of *Nepharis* on the stems, when the plant is roofed in by Irids, but they are difficult to take there, but by shaking into a bag I certainly got more than I expected, and hope to try the bag again before long."

Some of the species here recorded are certainly not ants'-nest beetles in the ordinary sense, but having been taken in nests they are included, as with long records such species may be frequently recorded as being found there, and their presence not at all accidental.[3] At the same time it appears probable that certain specimens were really dragged into ants' nests

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1 The minute size and narrow body of this insect no doubt deceived Mr. Davey on his preliminary examination, and in fact until carefully examined it is like many of the smaller *Staphylinidae*. Its wings, too small for flight, are folded much as in the species of *Thrips*.

2 Neither of these is a true ants'-nest beetle; the *Achopera* may be taken in abundance under bark and on rotting wood in all the Australian States: it was probably swept into the bag from the cranberry foliage, as also the other minute weevil. The latter, in general appearance, is like a very small *Bagous*, but with much shorter and wider tarsi, although not quite as in *Niphobolus deceptor*.

3 In this connection see H. St. J. Donisthorpe in Trans. Ent. Soc. London, 1909, p. 397. He also refers to it as to a well-known fact that many ants'-nest beetles are to be found in the nests of birds, hedgehogs, moles, etc.

against their will, and on the nest being disturbed by the covering stone being removed, such victims temporarily regained their liberty.

In addition to the species now recorded a very small flavous beetle was seen in fair numbers in a nest of white ants on the Richmond River, but all were extremely active, and managed to escape with one exception, which was rather badly crushed. Its antennae are clavate, and it has a conspicuous curved stria on each side of the prothorax. It is in anything but good condition for examination, but such as it is Mr. Blackburn suggests the possibility of its belonging to the *Erotyllidae*. Mr. Elgner also sent some large larvae as from white ants' nests. One is almost three inches in length, and evidently belongs to the *Carabidae* (probably *Feronides*). A second species (two of it sent) is about an inch and a-half in length, with a very large body and minute head; it is evidently Coleopterous, but I have no idea as to its family. A third larva evidently belongs to the *Erotyllidae*, but is too large to belong to the species here described as *Episcaphula termitophila*.

As some of the species are very singular I was unable to place them in their families or genera at sight, and being usually represented by single specimens, that it was inadvisable to destroy in examining their mouth parts, I sent some to the Rev. T. Blackburn for his opinion, and one to Mr. George Lewis, and under such species their opinions are herein given.

This paper is purely systematic; as although the relations existing between the ants and their guests, often very unwelcome ones, are very interesting; it was not now considered advisable to deal with such relations, as they would have unduly lengthened an already long paper, and are best considered separately.

For most of the names of the ants, bees and termites I have to thank Mr. W. W. Froggatt. Many of the beetles, however, were unfortunately simply noted as being from nests, without specimens of the ants, etc., being saved for reference. The known hosts are as follows:—

ANTS.

Amblyopone australis, Er.
Camponotus aeneopilosus, Mayr.

Camponotus dorycus, Smith.
Camponotus nigriceps, Mayr.
Camponotus novae-hollandiae, Mayr.
Colobopsis gasseri, Fab.
Dolichoderes scabaridus, Roger.
Ectatomma metallicum, Smith.[1]
Ectatomma reticulatum, Forel.
Ectatomma socialis, Macl.[2]
Iridomyrmex glaber, Forel.
Iridomyrmex gracilis, Lowne.
Iridomyrmex nitidus, Mayr.
Iridomyrmex rufoniger, Lowne.
Leptomyrmex detectus, Smith.
Lobopelta excisa, Mayr.
Myrmecia forficata, Fab.
Myrmecia pyriformis, Fab.
Pheidole bos, Forel.
Pheidole concentrica, Fab.
Pheidole conflicta, Forel.
Pheidole tasmaniensis, Mayr.
Ponera lutea, Mayr.
Podomyrma gratiosa, Smith.

Bees.

Trigona carbonaria, Smith.
Apis mellifica, Linne.

White Ants.

Coptotermes lacteus, Frgt.
Coptotermes raffrayi, Wasm.

The beetles are as follows:—

Carabidae.

On commencing the present paper Mr. T. G. Sloane was asked as to whether he knew any *Carabidae* that could really be regarded as ants'-nest beetles. In reply he wrote:—"I have

1 This species has numerous varieties.
2 Probably *Ponera lutea*.

always thought that the species of *Silphomorpha* are, in the imago state, predatory on the little black ants that frequent trees; Dodd holds the same view, and sent me a species of *Silphomorpha* with an ant on a card, with the note that it was a devourer of these ants. I have seen *S. suturalis* beset by ants, and killing them, but the ants were too plentiful and lively for it to have any chance of making a dinner. The *Pseudomorphini* are the only Carabs that I know of as being anteaters."

Adelotopus celeripes, n.sp. (Fig. 1.)

Black, highly polished; appendages bright red, tarsi somewhat darker. Margins of elytra with pale and almost regular setae.

Head about twice as wide as long, with an extremely faint median line; punctures absent. *Prothorax* about three times as wide as the length down middle, apex emarginate to receive the head to half-way between the eyes; margins moderately wide; median line short and very indistinct; punctures very minute and vague. *Elytra* with a strong puncture or small fovea on each side of base close to suture; with moderately dense and very minute punctures, and with some slightly larger ones forming feeble rows; margins narrow and very finely serrated. *Abdomen* with rather small punctures transversely arranged. Length 5, width $2\frac{3}{4}$ mm.

Hab.—W. Australia: Swan River (A. M. Lea).

Readily distinguished from all other species known to me by its great width (even more than that of *brevipennis*), high polish (as in *politus*), and uniformly coloured elytra (not even diluted with red at the tip), on which are two conspicuous sub-basal punctures. Several other species have such punctures, but are narrower or have the elytra not entirely deep black. In most of the black species of *Adelotopus* the sterna and abdomen are red, but in this species they are as dark as the upper surface. The seriate punctures on the elytra are visible only from certain directions.

One of the two specimens before me was taken from the nest of a stingless "sugar" ant, probably of the genus *Camponotus;*

it was extremely active, and I had to strike it quickly (and in so doing broke one of the elytra) to capture it.[1] Of the other specimen I have no record as to how it was taken.

Adelotopus variolosus, n.sp.

Black, highly polished; pygidium, metasternum, abdomen and appendages reddish; glabrous.

Head regularly convex, more than twice as wide as long; without punctures or median line. *Prothorax* about twice as wide as long, apex emarginate to receive head up to about one-third the length of eyes; margins moderately wide; punctures very indistinct. *Elytra* with very minute punctures, and with rows of very minute but slightly larger ones; margins narrow and not at all serrated. *Abdomen* with rather small and fairly numerous punctures. Length $7\frac{1}{2}$, width $3\frac{1}{2}$ mm.

Hab.—N.S. Wales: Sydney (A. M. Lea).

The proportions are almost as in the common *dytiscoides*, but it differs from that species in being smaller, more polished, and with the fine sculpture very different. Scattered over the upper surface are numerous small, small-pox-like impressions, or the marks made in drying mud by rain, and they are shallower and larger on the prothorax than on the elytra, but although distinct enough on close scrutiny, they are not very conspicuous. I have not seen similar impressions on any other species. The polish is almost as high as in *politus*, but that species is smaller and narrower, with the fine sculpture different. *Brevipennis* has the proportions much the same, but is smaller, and with the fine sculpture different. From certain directions the extreme tip of the elytra appears to be diluted with red, but from others the elytra appear entirely black.

The type was obtained under a stone from a nest of ants; several other specimens probably belonging to the species were seen associated with ants near Sydney, under stones, but they managed to escape capture by their extreme agility. The type was sent shortly after its capture to Mr. Sloane, and returned

1 Judged by their outlines and short legs one would think that the species of *Silphomorpha* and *Adelotopus* would be amongst the slowest of all the *Carabidae*, but as a matter of fact some of them are amongst the quickest moving beetles known.

as unknown to him. The whole of its appendages are damaged, but the parts that are left are of the same shade of red as the abdomen.

Adelotopus fasciatus, Cast.

Fairly common in nests of a small blackish-brown ant that occurs under bark of several species of *Eucalyptus* and *Banksia* about Sydney.

Philophlaeus, sp.

A single specimen of this genus was taken from under an old log in a nest of *Colobopsis gasseri*, and its presence there some distance from the nearest living tree could hardly have been accidental. It is closely allied to *quadripennis*, *obtusus* and *truncatus*, but with the hind angles of the prothorax more strongly rounded off. As the markings of the species of this genus are often very variable, and I have seen but the one specimen, it is not now dealt with in full.

Thenarotes discoidalis, Blackb.

Mr. Davey sent a specimen of this species as having been taken in the nest of a small black ant in a log. It was probably there by accident, however.

Tachys olliffi, Sloane.

Mr. Davey sent a single specimen as having been taken from an ants' nest at Portland (Victoria), and wrote: "This is the same beetle that I have seen five or six of in one nest in a rotten log on the Gellibrand River, but I was not too keen on them at the time, and they soon got out of sight, but there is little doubt, I think, that it associates with ants."

STAPHYLINIDAE.

Falagria fauveli, Sol.

A single specimen of this species was taken on Mount Wellington, Tasmania, right in the centre of a large nest of *Colobopsis gasseri*. It moved freely amongst the ants, who did not

interfere with it in any way. The species is common under logs which have most of their under surface free from the ground: and, although often seen near ants' nests, I cannot remember seeing more than this one specimen actually in a nest.

Myrmedonia clavigera, Fvl.

One specimen taken in a nest of a small red ant.

Polylobus semiopacus, n.sp.

Head, elytra and metasternum piceous-brown, prothorax somewhat paler, abdomen testaceous, towards apex somewhat darker; legs and palpi flavous; antennae smoky brown, but basal joints somewhat paler. Head, prothorax and elytra opaque, abdomen shining.

Head slightly transverse, base rounded. Eyes small. Antennae slightly passing base of prothorax, slightly thickened towards apex, most of the joints transverse. *Prothorax* lightly transverse, front angles obtusely rounded, hind angles almost rectangular, sides almost parallel, a wide shallow depression on each side; with dense, minute punctures. *Elytra* not much wider than prothorax, sides very feebly dilated posteriorly: with dense, small punctures. *Abdomen* about half total length, parallel-sided. margins strongly raised, especially towards base; punctures indistinct. Length $1\frac{1}{2}$, to apex of elytra $\frac{3}{4}$ mm.

Hab.—Tasmania: Hobart, Huon River, Launceston. In nests of *Ectatomma metallicum* (A. M. Lea).

The elytra are usually diluted with testaceons towards the base; the apical half of the abdomen is somewhat darker than the basal half, but there is no sharply defined meeting of the shades of colour. The prothorax, although paler than the head, is never so pale as the base of the abdomen.

Readily distinguished from all the following species by the opaque head, prothorax and elytra, with the prothorax shallowly bifoveate, although from some directions the impressions are indistinct.

On this and the five following species the clothing is much alike, and consists of dense fine pubescence on the lower surface of abdomen, rather sparser and longer on its upper surface, very

fine on elytra, and with the surface elsewhere glabrous or apparently so. The first six are from nests of the "green-head" stinging ant, and in size and colour are more or less alike.

The following table, in which, however, three species from the nests of other species of ants are included, may be of use in distinguishing them.

- Upper surface entirely black - - - - - - - *colobopsis*
- Upper surface not entirely black.
    - Elytra entirely pale - - - - - - - *pallidominor*
    - Elytra partly or entirely dark.
        - Prothorax decidedly opaque - - - - - *semiopacus*
        - Prothorax more or less shining.
            - Sides of prothorax gently rounded towards base.
                - Prothorax of uniform colour - - *ectatommae*
                - Prothorax paler at sides of base than on disc - - - *intrepidus*
            - Sides of prothorax oblique towards base.
                - Head opaque - - - - - *coxi*
                - Head shining.
                    - Head pale - - - - - *infuscaticornis*
                    - Head dark.
                        - Abdomen entirely pale *daveyi*
                        - Abdomen partly dark - *tasmaniensis*

Polylobus coxi, n.sp. (Fig. 28).

Of a dingy piceous-brown, head almost black; prothorax of a dingy red; legs somewhat flavous. Head opaque, prothorax and elytra feebly shining.

Head as long as wide, hind angles rather strongly rounded. Eyes small and fairly prominent. Antennae not passing base of prothorax, moderately thickened towards apex, most of the joints strongly transverse. *Prothorax* feebly transverse, front angles rather strongly rounded, sides feebly but distinctly decreasing in width, with straight outlines to base, hind angles rectangular, with a small feeble impression in middle of base; with dense minute punctures. *Elytra* flat, not much wider than prothorax, and visible portion along middle very little longer, sides very feebly increasing in width posteriorly; with

dense, minute punctures. *Abdomen* almost parallel-sided; punctures indistinct. Length $1\frac{1}{2}$, to apex of elytra $\frac{3}{4}$ mm.

Hab.—N.S. Wales: Sydney. In nests of *Ectatomma metallicum* (H. W. Cox).

The elytra and abdomen are almost of the same shade of colour, but the abdomen is more shining, from some directions, however, its apex appears to be somewhat paler. The palpi are somewhat darker than the legs, and somewhat paler than the base of antennae; the rest of the antennae, however, is much darker. The sides of the prothorax are very thin and appear to be separated from the disc (which in consequence appears fairly convex) by a shallow longitudinal impression, which, however, is nowhere well defined or foveate in character.

Polylobus tasmaniensis, n.sp.

Head, elytra and metasternum blackish brown, prothorax and abdomen of a dingy reddish testaceous, the median segments of the latter more or less stained with piceous; antennae piceous brown, basal joints slightly paler; legs and palpi somewhat obscurely flavous.

Head and antennae of much the same shape as in *semiopacus; prothorax, elytra* and *abdomen* also with similar outlines. *Prothorax* very feebly but evenly convex throughout, punctures indistinct. *Elytra* with dense, minute punctures. Length $1\frac{3}{4}$, to apex of elytra 1 mm.

Hab.—Tasmania: Hobart, Launceston, Huon River, in nests of *Ectatomma metallicum* (A. M. Lea).

The general outlines are almost exactly as in *semiopacus*, but the prothorax is without fovea, and is shining, as are also the head and elytra. It appears to be the commonest of all in Tasmania.

Some specimens have the elytra entirely dark, but in others they are slightly diluted with red towards the base. The dark median portion of the abdomen is distinct enough, but not sharply defined, and is usually more noticeable on the upper surface than the lower.

Five specimens from Hobart appear to belong to the species, but differ in having the head but little, or not at all, darker

than the prothorax, and the abdomen nowhere piceous. In colour, except that the elytra are darker, they agree with *infuscaticornis*, but have the head somewhat larger and the elytra wider.

Polylobus daveyi, n.sp.

Head, elytra and metasternum more or less piceous-brown, prothorax of a dull red, abdomen reddish testaceous; legs, palpi, and base of antennae somewhat obscurely flavous.

Head rather small and feebly transverse, hind angles strongly rounded. Eyes small and inconspicuous, antennae just passing base of prothorax, lightly incrassated towards apex, most of the joints distinctly transverse. *Prothorax* lightly transverse, front angles strongly rounded, sides then slightly oblique, basal angles rectangular; punctures very indistinct. *Elytra* more convex than usual, sides feebly rounded; with very feeble punctures. *Abdomen* rather narrower than usual, parallel sided throughout; margins rather strongly and evenly raised. Length 2 (vix), to apex of elytra 1 mm.

Hab.—Victoria: Forrest, in nests of *Ectatomma metallicum* (H. W. Davey); N.S. Wales: Sydney, in nests of same species of ant (A. M. Lea).

Rather more shining than *tasmaniensis*, obliquity of sides of prothorax more pronounced, and abdomen entirely pale: elytra uniformly darker than prothorax, although not very dark. The outlines of the prothorax are almost exactly as in *Coxi*, but the sides do not appear separated from the disc by a shallow longitudinal impression; in consequence the convexity is almost even throughout.

Two specimens from Tasmania (Launceston) differ in having the elytra diluted with red towards the base.

Polylobus infuscaticornis, n.sp.

Of a rather pale reddish testaceous; elytra entirely or towards apex, and metasternum slightly infuscated, antennae infuscate except basal joints; legs and palpi somewhat flavous.

Head rather small and feebly transverse, base rather strongly rounded. Eyes small but fairly prominent. Antennae compara-

tively thin, just passing base of prothorax, most of the joints rather lightly transverse. *Prothorax* and *elytra* with outlines and punctures as in preceding species. *Abdomen* feebly diminishing in width posteriorly. Length 2 (vix), to apex of elytra 4-5 mm.

Hab.—Victoria: Ararat, in nests of *Ectatomma metallicum* (H. W. Davey); N.S. Wales: Forest Reefs, in nests of same species of ant (A. M. Lea).

In build close to preceding species, but head smaller and entirely pale, and elytra paler. The pale head will readily distinguish from all the other species here described. The elytra, even in the darkest specimens, are not very dark.

Polylobus ectatommae, n.sp. (Fig. 29.)

Reddish testaceous, abdomen somewhat paler than prothorax, head more or less infuscated, elytra more or less piceous brown, but at base but little, or not at all, paler than prothorax, legs and palpi paler than abdomen, apical half or two-thirds of antennae infuscated. Head, prothorax and elytra feebly shining.

Head rather longer than wide, base rather strongly rounded. Eyes small and inconspicuous. Antennae rather thin, distinctly passing base of the prothorax, but few of the joints decidedly transverse. *Prothorax* lightly transverse, front angles moderately, the hind angles feebly rounded, sides very feebly rounded; base with three small and very feeble impressions; with dense minute punctures. *Elytra* very little longer and scarcely wider than prothorax, basal and apical angles rounded, sides elsewhere parallel, with dense minute punctures. *Abdomen* parallel, not much narrower than elytra; punctures feeble. Length 1 4-5, to apex of elytra .4-5 mm.

Hab.—Tasmania: Launceston, in nests of *Ectatomma metallicum* (A. M. Lea).

Several specimens have the head no darker than the prothorax, and two have the middle of the abdomen very feebly infuscated.

More parallel-sided and rather more depressed than any of the preceding species, and with the prothorax evenly rounded on

the sides, and scarcely oblique to the base, which is of equal width with the apex. In colour it is very close to the preceding species.

Polylobus colobopsis, n.sp.

Black, shining, legs of a pale dingy brown. With very short, indistinct pubescence.

Head about as long as wide, behind eyes almost parallel sided. Antennae extending to middle coxae, first joint about as long as three following combined, second longer than wide, third very small, fourth to tenth transverse and feebly increasing in width, eleventh ovate, slightly longer than ninth and tenth combined. *Prothorax* moderately transverse, sides and angles gently rounded, base and apex of even width; punctures indistinct. *Elytra* slightly wider than prothorax and about once and one-fourth as long, sides almost parallel; with small, dense punctures. *Abdomen* parallel-sided almost to apex; punctures indistinct. Length 1¼, to apex of elytra .2-3 mm.

Hab.—Tasmania: Mount Wellington, in a nest of *Colobopsis gasseri* (A. M. Lea).

The minute size and deep black colour readily distinguish this from all other species known to me. The disc of the prothorax on the type is slightly depressed, but this may be due to accident, as the depression is not quite median.

Polylobus intrepidus, n.sp.

Of a rather dingy brownish flavous, some parts darker. With short, pale and moderately dense pubescence.

Head feebly transverse, sides gently rounded; antennae slightly passing middle coxae, first joint moderately long, second slightly longer than wide, third and fourth small, fifth to tenth transverse and of almost even width, eleventh elongate-ovate, the length of three preceding combined. *Prothorax* moderately transverse, sides and base gently rounded; punctures indistinct. *Elytra* very little wider than prothorax, and along middle no longer; almost parallel-sided; with dense and very small punctures. *Abdomen* parallel sided almost to apex; with dense, minute punctures. Length 1½, to apex of elytra ¾ mm.

Hab.—Tasmania: Huon River (A. M. Lea).

The evenly rounded base of prothorax and bi-coloured elytra readily distinguish from the species associated with *Ectatomma metallicum.* In many respects close to the description of *tasmanicus,* but the colours dingy, abdomen with less of the segments dark, elytra not subtriangularly marked about the suture, and not "considerably longer than the prothorax," punctures of the latter not moderately strong, etc.

The head, upper surface of fourth abdominal segment, hind angles of elytra to a large extent, and the suture, are blackish brown, or at least much darker than the other parts; on the elytra the dark parts are not sharply limited, but extend almost to the shoulders and suture. The second to fourth abdominal segments on the under surface are moderately infuscated; the hind angles of the prothorax are slightly diluted in colour; the legs are uniformly of an almost clear flavous; the antennae are about the same at the base, but the apical joints are feebly infuscated. From some directions the prothorax appears to have a large shallow depression on each side at the base, but this appearance is due solely to colour. The abdomen is curiously distorted at the apex in the two specimens before me, but as this may be due to violent protrusion of the genital organs, it is perhaps best not formally described as of specific importance.

On turning over the stone covering these beetles the ground was seen to be swarming with the small black *Colobopsis gasseri* and a "jumper," *Myrmecia.* Almost as soon as it was turned a series of battles was waged between the two species of ants, but amongst them the beetles moved with unconcern. I would have liked to have examined the nests at length, but the jumpers were getting rather too familiar.

Polylobus pallidominor, n.sp.

Of a rather dingy flavous; basal half of head and third and fourth abdominal segments stained with brown. With moderately dense, short, pale pubescence.

Head distinctly transverse, sides moderately rounded. Antennae short, not extending to base of prothorax, most of the joints transverse, eleventh briefly ovate, slightly longer than

ninth and tenth combined. *Prothorax* rather strongly transverse, sides rather strongly rounded, base feebly rounded and slightly wider than apex; with dense minute punctures. *Elytra* scarcely wider than prothorax, and along middle a trifle shorter, sides parallel; punctures very small and dense. *Abdomen* parallel sided except at tip; with dense minute punctures. Length $1\frac{1}{4}$, to apex of elytra 2·3 mm.

Hab.—N.S. Wales: Sydney, in a nest of *Iridomyrmex rufoniger* (H. W. Cox).

A pale minute species.

Calodera cuneifera, n.sp.

Black, appendages piceous-brown. With rather dense, short pubescence, sparser and slightly longer on abdomen than elsewhere; sides, except of head, with sparse and moderately long setae, on abdomen at apex of segments as well as on sides.

Head lightly transverse, sides rather strongly rounded; with dense minute punctures. Antennae passing middle coxae, first joint as long as second and third combined, second very little longer than third, fourth to tenth transverse, the fourth and fifth slightly narrower than the others, which are of even width, eleventh almost as long as four preceding combined. *Prothorax* almost twice as wide as long, sides and base moderately rounded, the latter not much but distinctly wider than apex; punctures dense and very minute. *Elytra* at base no wider than prothorax and very little wider at apex, along middle no longer; punctures dense and very minute. *Abdomen* long, the five basal segments parallel-sided, thence tapering to apex; punctures indistinct except posteriorly. Length 3, to apex of elytra $1\frac{1}{4}$ mm.

Hab.—Victoria: Ararat, from a nest of *Ectatomma metallicum* (H. W. Davey).

Differs from *atypha* in being considerably narrower and less polished, antennae not conspicuously paler at base than at apex, and pubescence of prothorax and elytra denser, finer and more depressed.

The apical joint of antennae from one direction appears to be parallel-sided, with the apex gently rounded; from another direction it is seen to diminish in width from the base to the

apex; so as to be wedge-shaped, as in some of the species of *Dabra;* the eighth, ninth and tenth joints from some directions appear to be quite regularly transversely oblong.

Calodera punctiventris, n.sp.

Bright reddish castaneous, elytra and parts of fifth and sixth abdominal segments darker, appendages flavous or reddish flavous. With moderately short and fairly dense pubescence, longer and sparser on abdomen than elsewhere; sides, except of head, with sparse and moderately long setae.

Head rather small, very little wider than long, sides evenly rounded; punctures indistinct. Eyes prominent. Antennae comparatively thin, scarcely passing middle coxae, first joint as long as second and third combined, second not much longer but distinctly wider at apex than third, fourth shorter than third, but not transverse, fifth to tenth transverse, and gradually increasing in width, eleventh rather briefly ovate, about the length of ninth and tenth combined. *Prothorax* not much wider than long, scarcely the width of head across eyes, sides and base very feebly rounded, the latter about the width of apex, which is truncate; punctures dense and minute. *Elytra* very distinctly wider than prothorax, but along middle no longer, shoulders rounded, sides parallel; punctures rather more distinct than on prothorax. *Abdomen* long, parallel-sided to about the middle, thence gradually tapering to apex; each segment with dense and rather coarse punctures at the base, becoming smaller or disappearing posteriorly. Length 3, to apex of elytra 1 mm.

Hab.—Victoria: Ararat, in a nest of *Ectatomma metallicum* (H. W. Davey).

The head is a trifle darker than the prothorax, the elytra are less noticeably stained with brown about the sides and base than elsewhere, but at a glance appear of an almost uniform shade of colour. The fifth abdominal segment, except its margins and tip, and the basal half of the sixth, except its margins, are almost black.

Calodera laticollis, n.sp.

Pale reddish castaneous, disc of elytra slightly infuscated, head almost black, except muzzle; abdomen with dark parts as

in preceding species; appendages flavous, but antennae slightly infuscated, except towards base. Clothing as in preceding species.

Head distinctly transverse, sides behind eyes (which are not specially prominent) very feebly rounded; punctures small and indistinct. Antennae as in preceding species, except that the fourth joint is transverse. *Prothorax* almost twice as wide as the length down middle, sides and base rather strongly rounded, the latter distinctly wider than apex; punctures very minute, but with a few larger (but still small) ones forming a transverse series near base. *Elytra* slightly wider than prothorax, and scarcely longer along middle; sides feebly dilated to apex; with dense and small, but fairly distinct, punctures. *Abdomen* parallel-sided to beyond the middle, and then feebly tapering to apex; with rather dense punctures, on the four basal segments coarser at base than elsewhere. Length 2½, to apex of elytra 1 mm.

Hab.—Tasmania: Bagdad, in a nest of *Ectatomma metallicum* (A. M. Lea).

In general appearance very close to the preceding species, but eyes less prominent, prothorax less convex, and wider than head, instead of narrower, and antennae somewhat infuscated towards apex; the stronger abdominal punctures are also somewhat smaller and are not present on all the segments.

Homalota australasiae, n.sp.

Of a pale dingy brown, head, elytra and fourth and base of fifth abdominal segments darker, legs almost flavous, antennae about the same at base but slightly infuscated towards apex. With moderately dense, but extremely short pubescence.

Head moderately transverse, sides evenly rounded, antennae just passing base of prothorax, first joint moderately long, second slightly longer than wide, third small, fourth to tenth transverse and of almost even width, eleventh ovate, slightly longer than ninth and tenth combined. *Prothorax* about once and one-half as wide as long, sides and base gently rounded, the latter scarcely perceptibly wider than apex; punctures dense and minute. *Elytra* slightly wider than prothorax, and about

once and one-half as long, sides parallel, punctures dense and minute. *Abdomen* long and parallel sided almost to apex; punctures minute and indistinct. Length $1\frac{1}{2}$, to apex of elytra $\frac{3}{4}$ mm.

Hab.—Victoria: Forrest (H. W. Davey), Emerald; Tasmania: Mount Wellington, Hobart, Huon River, Swansea; N.S. Wales: Sydney, Forest Reefs, Dalmorton; W. Australia: Swan River, Karridale, Albany, Bridgetown, Pinjarrah (A. M. Lea).

In general appearance like *atyphella* but somewhat paler and much smaller. On some specimens the elytra are but little, or not at all, darker than the prothorax; the dark parts of the abdomen are sometimes extended to the second and sixth segments; the head is occasionally black, but as a rule is of a rather dark brown.

Mr. Davey sent two specimens as from the nest of a small black ant in a log, on another occasion he sent twenty-five as from close to a nest of the same species of ant. Most of the specimens taken by myself were from flood debris.

Dabra nitida, n.sp. (Fig. 2.)

Shining. Reddish castaneous; elytra and several abdominal segments slightly stained with piceous. Very finely pubescent, a few setae at sides of abdomen; hind angles of prothorax and elytra each tipped with a seta.

Head slightly swollen behind the eyes, and somewhat flattened between them. Antennae longer and thinner than in other species of the genus, and passing base of prothorax, first joint slightly longer than second and third combined, eleventh as long as ninth and tenth combined, some of the intermediate joints wider than long, but none strongly transverse. *Prothorax* about twice as wide as long, very flat, sides not channelled, but a vague depression on each side in front, apex feebly incurved to middle, front angles rounded; base distinctly wider than apex, and bisinuate, hind angles acute; with minute punctures, more noticeable on sides than elsewhere. *Elytra* about as long and as wide as prothorax, sides not channelled, hind angles acute; with dense, minute punctures. Upper surface of *abdomen* with a row of small setiferous punctures at the apex

of each segment. *Legs* rather long and thin. Length 3½, to apex of elytra 1 2-3 mm.

Hab.—Victoria: Sea Lake and Birchip (J. C. Goudie), Geelong (H. W. Davey). In nests of *Iridomyrmex nitidus.*

All the other known species of the genus have several joints of the antennae strongly transverse. The prothorax nonsetose at the sides associates this species with *termitophila,* from which it is readily distinguished by its highly polished and considerably flatter prothorax, with the elytra not channelled at the sides and the antennae considerably longer.

Dabra termitophila, Lea.

There is a specimen from Hobart (the only Tasmanian example before me) which I cannot distinguish from the types, but it differs in being somewhat smaller (2¼ mm.) and slightly narrower, with the antennae rather more inflated in the middle. It may represent a variety, but it does not appear desirable to name it as a variety without seeing additional specimens.

The original specimens were from a nest of *Coptotermes raffrayi.*

Dabra termitophila, Lea, var. *victoriensis,* n.var.

Messrs. J. C. Goudie and H. W. Davey have sent from Sea Lake and Geelong numerous specimens of a species, which appears too close to *termitophila* to be regarded as distinct, but which differ from the types of that species in having the prothorax slightly more convex, and with less channelled sides. In the types of *termitophila* the channel on each side is well marked and continuous from apex to base, although narrowing posteriorly; as a consequence the margins appears to project almost horizontally. In the present variety the channel on each side usually does not extend more than two-thirds of the way to the base, and on several specimens is confined to the apical fourth or even less; on one specimen, in fact, the channels are absent; as a consequence the margins, or the greater portion of them, appear to project obliquely downwards. The Victorian specimens were taken in the nests of *Iridomyrmex nitidus.*

Dabra convexicollis, Lea.

Occurs in nests of *Ectatomma metallicum*.

Dabra myrmecophila, Oll.

Recorded originally as from ants' nests. Messrs. Goudie and Davey have taken it in nests of *Iridomyrmex nitidus*.

Dabra cuneiformis, Oll.

Recorded originally as from ants' nests.

Dabrosoma, n.g.

Head rounded at the base. Eyes small and mediolateral. Prothorax almost truncate at apex, bisinuate at base, with the hind angles feebly produced. Other characters much as in *Dabra*.

In *Dabra*, although not mentioned in the original description, the head is closely applied to the prothorax, and produced on each side at the base into a rather acute angle, and the eyes are sub-basal.[1] In the present genus the head is rounded on each side of the base, and the eyes are much smaller and more median.

Dabrosoma pubescens, n.sp. (Fig. 3.)

Of a dull reddish brown, head and prothorax stained with piceous, median segments of abdomen almost black. Finely pubescent all over, except upper surface of four basal segments of abdomen, which are shining and each with a row of small setiferous punctures; a few small setae at sides of prothorax, elytra and abdomen.

Head rounded, obtusely produced between antennae, with indistinct punctures. Antennae passing base of elytra, not very thin, first joint stouter and about as long as second and third combined, these sub-equal in length and sub-triangular, fourth to tenth gradually increasing in width, but none more than moderately transverse, eleventh somewhat wedge shaped, slightly

1 The figure of the head (Proc. Linn. Soc. N.S. Wales, vol. i., 2nd series, pl. 7, fig. 2), is misleading.

longer than three preceding combined. *Prothorax* feebly convex, more than twice as wide as long, front angles obtusely rounded, hind very feebly produced, base not much wider than apex; with dense minute punctures. *Elytra* slightly longer, but not wider than prothorax, apex feebly sinuous; with dense minute punctures. *Abdomen* strongly margined, parallel-sided to rear apex; about apex with small dense punctures. *Legs* rather long and thin. Length 1, to apex of elytra 2¼ mm.

Hab.—Tasmania: Hobart, Parattah, in nests of *Colobopsis gasseri* (A. M. Lea); Victoria: Geelong, in nest of *Iridomyrmex nitidus* (H. W. Davey).

The prothorax usually has its angles somewhat paler than the disc. One small specimen has the abdomen entirely dark. Two have the abdomen terminated by a peculiar process, somewhat like the closed forceps of an earwig; but this has probably been forced out, as in the other specimens it is not visible.

Termophila, n.g.

Head rounded, of moderate size. Eyes round, lateral, finely faceted. Antennae inserted slightly in front of and close to inner margin of eyes, slightly thickened externally, eleven-jointed. Labial palpi two-jointed. Maxillae with numerous spines. *Prothorax* strongly transverse, sides strongly rounded; all angles rounded. *Scutellum* small and normally not visible. *Elytra* short, outline subcontinuous with that of prothorax. *Abdomen* strongly margined, sides feebly decreasing in width. *Mesosternum* with a narrow keel separating the middle coxae. *Femora* stout; tibiae rather short and thin; tarsi thin, two front pair four-jointed, the hind pair five-jointed.

In Olliff's table of the *Aleocharina* (Proc. Linn. Soc. N.S. Wales, 1886, pp. 408-9) this genus would be placed with *Placusa*, from his description of which it differs in the maxillae and rounded head, etc. In some respects it is close to *Dabra*, but differs in head, antennae, hind angles of prothorax, and in the tarsi. Specimens of *latebricola* were sent to the Rev. T. Blackburn some years ago, and he wrote of them: "No doubt an *Aleocharid*. A most delightful little thing of no genus known to me."

Termophila latebricola, n.sp.

Testaceous-brown, abdomen and appendages paler, as also the margins of the prothorax, and margins and suture of elytra; mouth parts pale flavous. Shining. Head, prothorax and elytra with a few straggling setae, not confined to sides; abdomen with more numerous ones on upper surface, mostly confined to apex and sides of the segments; on under surface somewhat more evenly distributed.

Head smooth, base rounded, gently convex. Eyes not very large. Antennae passing base of prothorax, first joint about once and one-half the length of second, second to tenth subequal in length but gradually increasing in width, tenth about once and one-half as wide as long, eleventh about as long as ninth and tenth combined. *Prothorax* scarcely twice as wide as long, regularly and rather strongly convex, but with very narrow reflexed sides, sides rather strongly rounded, front angles strongly rounded, hind ones moderately so, base very gently rounded. *Scutellum* small and usually concealed. *Elytra* slightly longer than prothorax, regularly convex. *Abdomen* about half total length, decreasing in width hindwards, five basal segments strongly margined. Length 2¼, to apex of elytra 1¼ mm.

Hab.—N.S. Wales: Galston, in nest of termites (A. M. Lea).

The upper surface of the abdomen is often paler than the elytra, but sometimes is just as dark. The appendages, however, are always paler, but the mouth parts, even in apparently immature specimens, are always much paler (almost white). The head, prothorax and elytra are without punctures, as is also the abdomen, except for reception of setae. In nearly all the specimens the abdomen is curled upwards to its tip.

Obtained in abundance from a termites' nest in the pipe of a large "Iron-Bark." Hundreds of specimens could have been taken on the only occasion when the species was found. Many of the specimens are entirely pale, perhaps from immaturity.

Termophila punctiventris, n.sp. (Fig. 4.)

Testaceous brown, prothorax slightly paler than head or elytra, abdomen still paler, but with the fifth segment piceous;

appendages of a rather pale testaceous. Shining. Head glabrous, prothorax and elytra with short sparsely distributed setae; abdomen with rather sparse but more noticeable setae, more or less confined to apex and sides of the segments.

Head wide, somewhat flattened in middle. Eyes rather small. Antennae extending almost to apex of elytra, first joint moderately long, second to tenth subequal in length, but gradually increasing in width, eleventh as long as ninth and tenth combined, and obtusely rounded at apex. *Prothorax* gently convex, twice as wide as long, wider than head and at base the width of elytra, front angles strongly, the hind ones moderately rounded, apex gently incurved to middle, base gently but distinctly rounded. *Scutellum* transverse and distinct. *Elytra* along middle somewhat shorter than prothorax, but longer at sides, hind angles somewhat acute. *Abdomen* with four basal segments sub-parallel and strongly margined, the others distinctly decreasing in width, and only the fifth with a margin (which is much less distinct than on the basal ones), fourth longitudinally strigose on upper surface, fifth with very distinct punctures on both surfaces, sixth feebly punctate, apex semicircularly emarginate. Length 2½, to apex of elytra 1½ mm.

Hab.—W. Australia: Bridgetown, in a nest of white ants (A. M. Lea).

A highly polished and (except for the abdomen) impunctate species like the preceding, but with prothoracic margins (which, although slightly upturned or flattened at the hind angles, are not narrowly reflexed) different, and with a distinct scutellum. It possibly should have been referred to a new genus, but having but one specimen I have not ventured to risk breaking it to make sure of this, nor have I been able to count the tarsal joints. It should, however, be readily identified amongst the Australian *Staphylinidae* by its peculiar fifth abdominal segment.

Conosoma activum, Oll.

One specimen sent by Mr. Davey as having been taken in the nest of a small black ant in a log.

Conosoma rufipalpe, Macl.

Taken by Mr. H. W. Cox in a nest of *Ponera lutea*.

Conosoma barycephalum, Lea.

Taken in a nest of *Camponotus Novae-Hollandiae.*

Conosoma myrmecophilum, Lea.

The type was taken from an ants' nest.

Scopaeus latebricola, Blackb.

Mr. Cox sent three specimens of this species as having been taken from a nest of *Iridomyrmex rufoniger.*

The type was from flood debris in S. Australia. I have also taken the species in flood debris in N.S. Wales.

Sunius aequalis, Blackb.

An occasional visitor to ants' nests under stones. Mr. Davey has also taken the species from nests of a small black ant in logs.

Oxytelus sparsus, Fvl.

Two specimens of this very common dung beetle were sent by Mr. Davey as having been taken in a nest of *Ectatomma metallicum.*

Oxytelus micropterus, Lea.

One specimen taken from a nest of *Iridomyrmex gracilis*, but possibly there by accident.

Lispinus sidneensis, Fvl.

Mr. H. W. Cox writes that he has taken this species in a nest of *Termes lactis.* It is a common species under bark in the coastal districts of N.S. Wales.

Trogophlaeus myrmecophilus, n.sp.

Black, sub-opaque, legs (femora more or less piceous), palpi and basal joint of antennae obscurely testaceous. Very finely pubescent.

Head with a shallow groove on each side between eyes; with small dense punctures. Antennae passing base of prothorax, first joint rather large, second slightly longer and distinctly thicker than third, the others feebly increasing in width. *Prothorax* lightly transverse, wider at apex than at base, the

width of head, but slightly narrower than elytra (at base much narrower), with two distinct curved impressions, a rather short one in middle, and a longer one at base so curved as almost to extend to the apex on each side; punctures as on head and elytra. *Elytra* subquadrate, shoulders square, sides parallel, apex gently incurved to middle. *Abdomen* parallel-sided, sides strongly margined; punctures dense and small. *Legs* rather short. Length 1¼, to apex of elytra 2-3 mm.

Hab.:—N.S. Wales: Sydney, three specimens from a nest of *Iridomyrmex rufoniger* (H. W. Cox).

The elytra are quite as black as the rest of the upper surface. The impressions on the prothorax are separated by a slight ridge, the basal one is somewhat interrupted, so that from some directions it appears to consist of several shallow transverse or slightly curved foveae.

Of the size of *exiguus*, but with prothorax distinctly sculptured and legs paler.

Eleusis nigriventris, n.sp. (Fig. 5.)

Castaneous, abdomen black.

Very flat. *Head* almost parallel-sided behind eyes, hind angles gently rounded, with a short narrow neck, front somewhat produced between antennae and obtuse, with two strong median impressions not quite continued to base, and a finer but continuous impression on each side; with fairly large, clearly defined punctures. Eyes small, projecting, and at one-third from apex. Antennae inserted on extreme sides half-way between eyes and apex, eleven-jointed, rather thin and of almost uniform thickness; first slightly stouter and about once and one-fourth the length of second, second slightly longer than third, and third than fourth, fourth to tenth slightly transverse, eleventh obovate, almost twice the length of tenth. *Prothorax* slightly narrower than head, moderately transverse, widest at apex, thence with oblique sides to base; punctures smaller than on head, and forming two almost regular median lines, the space between which is impunctate. *Scutellum* equilaterally triangular, impunctate. *Elytra* oblong, about one-fourth longer than wide, and the width of head; with denser but smaller punctures

than on prothorax. *Abdomen* about as long as prothorax and elytra combined, sub-parallel sided to near apex. Length $2\frac{3}{4}$, to apex of elytra $1\frac{1}{2}$ mm.

Hab.—Victoria: Portland (H. W. Davey); Tasmania: Hobart (A. M. Lea).

The specimen from Portland was taken "under bark of a swamp gum in a nest of small black ants that run about with their abdomens cocked in the air." No record was kept as to how the Hobart specimen was taken.

It is with doubt that this species is referred to *Eleusis*, as the shape of the prothorax is very different to that of the two species (*planicollis* and *parva*) previously recorded from Australia, the head is of somewhat different shape, with strong impressions, the eyes are smaller and prominent, and the front coxae (which are comparatively small, subglobular and contiguous) are smaller and more rounded. The tarsi appear to be the same, but I am unable to decide as to the number of their joints, owing to the basal half being obscured by fine setose clothing; they appear to be three-jointed, with the two basal joints indistinctly separated and thin, the third long and thin, but inflated at apex, and with strong claws. Quite possibly, however, they are four-jointed, or even five-jointed, as their clothing renders them indistinct. They appear to be as in *planicollis*. The labial palpi are minute.

Under a compound power the whole upper surface appears covered with minute granules of uniform size. With a Coddington lens it appears densely and minutely punctate, with larger punctures scattered about. The abdomen at first appears to be immarginate, but on close examination a fine impressed line can be seen near the side of each segment. A few short setae are scattered about on the sides.

Glyptoma myrmecophilum, n.sp.

Reddish castaneous. Feebly shining. Apparently glabrous. *Head* obtusely triangular in shape, but with a distinct neck, obtusely bicarinated along middle and finely bicarinated on each side, with between the two lateral carinae a small elevation. Eyes rather small and lateral, very distinct from above, but

more so from below. Antennae rather short, eighth to tenth joints transverse, and, with the briefly oval eleventh, forming a loose club. *Prothorax* moderately transverse, sides almost parallel on apical two-thirds, but then suddenly decreasing to base; with a number of irregular costae, more numerous but less defined at apex than at base. *Elytra* as long as wide, almost square; each with at least six costae separating distinct rows of punctures. *Abdomen* about half total length, four basal segments narrower at base than apex, and each with a distinct row of punctures, fifth slightly narrowed to apex, sixth triangular. *Legs* rather short; front and hind coxae touching, middle almost touching. Length 2 1-6, to apex of elytra 1-1⅛ mm.

Hab.—Victoria: Forrest, four specimens from an ants' nest (H. W. Davey).

Under a Coddington lens the punctures, except on the elytra and abdomen, are indistinct, but with a compound power they are seen to be dense all over; under a compound power also, an extremely sparse golden pubescence becomes visible. The tarsi are apparently three-jointed. Seen directly from in front the head appears to have four longitudinal carinae placed at equal distances. From the sides the median carinae are indistinct, but the lateral ones more distinct and with a small elevation between them, immediately above the insertion of antennae. From behind or directly above it is difficult to make out the number or disposition of the carinae.

Differs from the description of *sculptum* in having the head with more than three carinae, and each elytron with more than four, and distinctly longer than the prothorax. The surface also is densely punctate. From the description of *sordidum* in being larger, and in the sculpture of upper surface; the length of its elytra, however, is apparently in the same proportion as in *sordidum*.

Glyptoma kingi, n.sp. (Fig. 6.)

Of an almost uniform and rather bright chestnut-red, apical joint of antennae somewhat paler. Apical segments of abdomen finely setose, appendages finely pubescent, elsewhere glabrous.

Head with a large obtuse semi-double tubercle in middle of base, a flattened ridge above each eye, the two ridges with their apices finely connected across middle of head. First joint of antennae about as long as second and third combined, second about as long as wide, the others feebly increasing in width and becoming more transverse, so that the tenth is more than twice as wide as long, eleventh briefly ovate. *Prothorax* not twice as wide as long, margins thin, flat and rounded, front angles somewhat acute and slightly produced, extreme base almost rectangular and the width of apex; with a strong narrow carina somewhat closer to each side than middle; with a shallow but distinct median line. *Scutellum* distinct, apex rounded. *Elytra* slightly wider and longer than prothorax; obtusely elevated on each side of suture, with two strong costae on each side, one forming the margin, the other close to it, the two conjoined on shoulder. *Abdomen* with segments gradually decreasing in width, closely applied together and elliptic in section. *Coxae* comparatively small, front and hind pair touching, middle pair almost touching; femora tibiae and tarsi thin. Length $2\frac{1}{4}$, to apex of elytra 1 mm.

Hab.—N.S. Wales: Liverpool (R. L. King), Sydney, in nests of *Iridomyrmex nitidus*[1] (H. W. Cox); Victoria: Birchip and Sea Lake, in nests of same ant (J. C. Goudie).

Under a Coddington lens the whole of the upper surface appears impunctate. From each side there appear to be two strong costae at the side of the head, prothorax and elytra. From some directions the cephalic tubercle appears to be single, but from behind it is seen, quite distinctly, to be double.

I refer this species with some doubt to *Glyptoma*, as although the tarsi appear to be three-jointed, it is not at all sure that there is not a small hidden basal joint. The strongly costate upper surface, however, seems out of place in any other genus than *Glyptoma* (unless a new genus should be erected for the species) the limits of which (as it occurs in other parts of the world) I am by no means sure of. The eyes, although very convex, are quite invisible from above from certain directions. The antennae and legs are apparently as in *myrmecophilum*, but the abdomen is very different.

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1 Mr. Cox has also recently taken it in a nest of *Ectatomma metallicum*.

The species is dedicated to the memory of the late Rev. R. L. King, the discoverer of many interesting ants'-nest beetles, some of which are still undescribed. In his collection (now in the Australian Museum) it was labelled as a *Dinarda*, but it is not even close to that genus, which (as noted by the late A. S. Olliff) is close to *Dabra*, and which has the abdomen strongly margined. In this species even the basal segments are immarginate.

PSELAPHIDAE.

The species of this family are often referred to as ants'-nest beetles, although many of them occur in moss, tussocks, under fallen leaves, etc. Still many of them do occur in nests of ants and termites. Of many of those recorded from Australia, the type specimens were obtained during floods, or on fence tops, etc., at dusk; when their connection with their hosts could not be ascertained; although they really are inhabitants of nests most of their lives. In many cases also the describers, although they were informed that specimens were obtained in such nests, failed to mention the same. This is also true of the *Staphylinidae* and *Scydmaenidae*. Whilst it is probable that some of the anomalous species of other families are also really ants'-nest beetles, although not so recorded.

Euplectops sculptus, King.

A specimen from Forrest (Victoria) sent by Mr. H. W. Davey, as from a nest of small black ants in a log, probably belongs to this species. It agrees well with the description, and is very close to a species named (with a query) by M. Raffray as *sculptus* from W. Australia; the latter specimen, however, has the median line of the prothorax rather feebly impressed, whilst the Forrest specimen has it more deeply impressed (in the original description King says "foveola elongata media" and also "the median impressed line or elongated foveola." King referred the species to *Bryaxis*, but in the index to *Euplectus*.

Euplectops gibbosus, King.

I have a specimen from King's collection, named as *Batrisus gibbosus*, and agreeing with his description. It is congeneric

with the preceding species, and readily distinguished from all others of that genus known to me by the very strong prothoracic sculpture. The type was from an ants' nest, and Mr. Davey has taken several specimens in the nests of *Iridomyrmex nitidus* at Geelong (Victoria).

In Raffray's recent monograph the species is referred to *Batrisodes*, but this is not surprising, as King did not state that three of the abdominal segments are strongly margined.

Euplectops odewahnii, King.

I have a co-type of this species, and also a specimen so identified by M. Raffray.

The species occurs in N.S. Wales, Victoria and Tasmania, as well as in S. Australia. Some of the Tasmanian specimens were obtained from moss. Two specimens sent by Mr. Davey were from the nest of a small black ant in a log.

Euplectops villosus, n.sp.

♀. Pale castaneous, appendages slightly paler. With very sparse and indistinct pubescence, but in addition with numerous, rather long, straggling, pale hairs.

Head with a strong curved median impression, behind which the surface is very convex and longitudinally impressed in middle; antennary tubercles distinct, the inter-space rather strongly depressed. Antennae rather thin, extending to base of prothorax, two basal joints rather stout, third to eighth small and subglobular, ninth somewhat larger but subglobular, tenth somewhat transverse, narrowed in front, eleventh subovate, slightly longer than three preceding joints combined, apex produced. *Prothorax* slightly longer than wide, widest just in front of middle, thence strongly narrowed to apex, near base strongly transversely impressed with three longitudinal impressions, the median one rather fine and not continuous to apex, the lateral ones shorter and deeper. *Elytra* about as long as wide, with eight small basal foveae, and with fairly distinct scattered punctures, subsutural and discal striae distinct, but the latter not continuous to apex. Upper surface of *abdomen*

with a feeble medio-basal node, on each side of which is a short oblique stria; lower surface rather strongly convex along middle. *Legs* rather thin. Length $1\frac{1}{2}$ mm.

Hab.—Victoria: Lovat, in nest of small black ant (H. W. Davey).

The type is probably a female, but was described as the secondary sexual characters in this genus are seldom very pronounced, and the numerous long straggling hairs with which it is clothed should render it very distinct. It is more convex and with decidedly longer hair than in *odewahnii*, and the base of the prothorax is not as in *sculptus*. The median line of the prothorax is continued across the basal impression, but the latter is not forced backwards in consequence, as it is in other species.

Plectostenus, n.g.

Head rather small. Eyes small. Antennae thin. Palpi small, with three joints visible, the first small and almost concealed, second thin, not very long and inflated at apex, third about as long as second, elliptic, ob-ovate and terminated by a seta. Under surface with a distinct conical projection on each side concealing base of palpi. *Prothorax* longer than wide, with a transverse sub-basal impression, median line absent. *Elytra* rather small, with two short dorsal striae on each. *Metasternum* and abdomen elongate. *Legs* rather long and thin; hind coxae almost touching; tarsi thin, first joint very short, second elongate, third somewhat shorter and terminated by a single claw.

Allied to *Macroplectus* but narrow, the club and abdomen and under surface of head different.

Plectostenus gracilicornis, n.sp. (Fig. 7.)

♂. Reddish castaneous, tarsi and palpi paler. With extremely fine pubescence.

Head strongly constricted near base; convex between eyes, with a minute central fovea; a rather large fovea close to each eye, and open in front. Antennae thin, basal joint par-

tially concealed, second moderately stout, about the length of first, but distinctly longer than the exposed portion of that joint, third to eighth each slightly longer than wide, ninth to eleventh forming a thin club, ninth about twice the length of eighth, and at base no wider, but slightly dilated to apex, tenth slightly shorter and wider than ninth, and very feebly transverse, eleventh about as long as ninth and tenth combined. *Prothorax* slightly longer than wide, sides widest and evenly rounded somewhat nearer apex than base; near base with a strong transverse impression marked by three small foveae, one in middle and one on each side; punctures indistinct. *Elytra* almost as long as wide, sides gently rounded, angles distinctly rounded; with six small basal foveae; each with two faint dorsal striae; punctures rather indistinct. *Abdomen* with segments rather long on upper surface, and with strong margins; the lower surface with a narrow, strongly ridged intercoxal process, second to fourth segments narrowed across middle, fifth strongly narrowed, and, with the fourth and sixth, flattened. *Metasternum* vaguely depressed along middle, but with a conspicuous sub-conical tubercle on each side, half way between coxae. Front *trochanters* very feebly dentate; four hind tibiae spinose at apex. Length 2 mm.

♀. Differs in having antennae somewhat shorter, abdomen almost parallel-sided, instead of rather strongly dilated posteriorly, and convex along middle of under surface; metasternum unarmed and tibiae without apical spines. Length 1 2-3 mm.

Hab.—W. Australia: Swan River, Bridgetown, from nests of *Ponera lutea* (A. M. Lea).

Seen from the side each eye appears to be at the point where two conical tubercles should meet, one concealing the base of the antennae, the other on the lower surface of head. In appearance the antennae are suggestive of some species of *Heterognathus* of the *Scydmaenidae*. The dorsal striae are very faint, and the two on each elytron are seldom visible from the same direction; they arise from the basal foveae, and are fairly distinct to the basal third, but are vaguely traceable to beyond the middle. The tubercles on the metasternum are very distinct from the sides.

Batrisodes myrmecophilus, n.sp.

♂. Reddish-castaneous. Clothed with fine, pale, subdepressed pubescence.

Head with a deep impression on each side, curved round and joined together in front so as to be shaped like an ∩, the apices subfoveate, the enclosed space rather strongly convex, and with a feeble median impression; with dense and fairly distinct punctures. Antennae extending to middle coxae, first joint slightly longer than second, the others to eighth very slightly shorter and narrower than ninth, this the length of but slightly narrower than tenth, eleventh briefly ovate, about half as long again as tenth. *Prothorax* slightly longer than wide, widest across middle, thence regularly decreasing to apex and irregularly to base; with a distinct median line not quite extending to apex, and terminated near base in a fovea; basal half irregular; punctures as on head. *Elytra* very little wider than long, shoulders obtusely dentate; each with a narrow sutural stria, and a lightly curved discal one, which, however, is not continued beyond the middle; punctures at base as on prothorax, but smaller elsewhere. *Abdomen* with dense and fairly distinct punctures; on each side of upper surface of three segments with a fine impressed line, under surface somewhat flattened along middle. *Metasternum* with a wide shallow impression. *Legs* rather long; hind trochanters each with a strong curved tooth, the median pair indistinctly dentate; femora rather stout; tibiae distinctly curved. Length $2\frac{1}{2}$ mm.

Hab.—Victoria: Sea Lake, in a nest of *Ponera lutea* (J. C. Goudie).

The absence of a cephalic carina and the structure of the head generally will readily distinguish from most species of the genus. In general appearance it is somewhat like *hamatus*. The base of the prothorax appears to consist of two lobes, with their convex ends in front, and at the side each appears from some directions to be dentate, but this is due principally to a deep medio-lateral impression; this impression is continued, with interruptions, to the base, and from some directions can be vaguely traced to the apex.

A specimen from Sydney, taken in a nest of the same species of ant, appears to be the female; it differs in being slightly

larger (2 2-3 mm.), shoulders more obtusely dentate, metasternum flattened and trochanters unarmed.

Batrisodes nobilis, King.

A single badly damaged male before me probably belongs to this species. It was taken at Galston from the nest of a white ant in the "pipe" of an "ironbark" eucalyptus tree. The type of *nobilis* was also from a white ants' nest at Parramatta (quite close to Galston), but King considered it was there by accident.

The head of the Galston specimen is much as in Raffray's figure of *ursinus*,[1] except that it has no basal carina. Each of its hind trochanters is armed with a small, acute, curved spine.

Batrisus angulatus, Westw.

Recorded originally as from ants' nests. The species is omitted from Raffray's recent monograph in Wytsman's Genera Insectorum. As the genus *Batrisus* is now defined, *angulatus* certainly cannot belong to it, as the abdomen is figured as being decidedly margined.

Batraxis armitagei, King.

Mr. Cox has taken single specimens of this species from nests of *Ponera lutea* and *Ectatomma metallicum*, near Sydney.

The species was referred to *Bryaxis* by King, to *Batrisus* by Schaufuss, and to *Batraxis* by Raffray.

Batraxis laevigata, Raffr.

The specimens described by M. Raffray were taken from a nest of *Camponotus aeneopilosus*.

Eupines hospes, n.sp.

♂. Blackish brown, elytra dark reddish-brown; legs pale castaneous, fifth and ninth to eleventh joints of antennae darker. Upper surface with conspicuous and rather long pale hairs.

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1 Proc. Linn. Soc. N. S. Wales, 1900, pl. x., fig. 27.

Head with a shallow but fairly distinct impression close to each eye, and a much less distinct one behind base of each antenna. Antennae with fifth joint inflated and briefly elliptic, ninth moderately, tenth strongly transverse, eleventh large and subovate, but somewhat lopsided. *Prothorax* widest at about one-third from apex. *Elytra* moderately dilated posteriorly, and comparatively large, dorsal striae traceable at extreme base only. *Metasternum* rather narrowly and not deeply impressed along middle. *Abdomen* with second segment rather vaguely impressed along middle. Front *trochanters* finely and acutely dentate. Length 1 mm.

Hab.—Victoria: Portland, in a nest of ants (H. W. Davey).

Darker and with much more conspicuous clothing than any other species known to me, with the fifth joint of antennae inflated. From *nigricollis* it also differs in the club. The metasternum is less strongly impressed than in *globulifer*, and the abdomen is longitudinally impressed.

The eleventh joint of antennae is not quite so dark as the ninth and tenth, but the difference is very slight.

Eupines flavoapicalis, n.sp.

♂. Castaneous, tip of abdomen flavous.

Head with small but fairly deep inter-ocular impressions, frontal ones very indistinct. Antennae with second joint slightly longer than wide, third to ninth short, tenth largest of all and feebly transverse, eleventh briefly ovate. *Prothorax* rather short, widest quite close to apex. *Elytra* rather short; dorsal striae vaguely traceable and only on basal slope. *Metasternum* rather largely impressed posteriorly. *Abdomen* with two small tubercles farly close together near apex of second segment, apical segment widely flattened in middle. Front *trochanters* subtriangularly dentate; middle tibiae somewhat inflated and conspicuously dentate just beyond the middle. Length 1—1¼ mm.

♀. Differs in having the tenth joint of antennae much smaller than eleventh (not half its length and somewhat narrower), metasternum impressed only between hind coxae, abdomen more convex and non-tuberculate, and legs edentate.

Hab.—N.S. Wales: Sydney (E. W. Ferguson and H. W. Cox); Victoria: Birchip and Sea Lake (J. C. Goudie); W. Australia; Donnybrook, Bridgetown (A. M. Lea).

The sexual characters are apparently somewhat as in *picta*, but neither Schaufuss nor Raffray make any mention of the conspicually pale tip of abdomen (affecting at least two segments on the upper surface, and one on the lower), and Schaufuss describes the head and abdomen of that species as darker than the other parts. Raffray describes it as generally unicolorous, but with the head and club sometimes darker, and his description of the male metasternum disagrees with this species. *Militaris* is described as having somewhat similar middle tibiae and abdomen, but the colour and tenth joint of antennae are very different. *Capitata* has the head differently impressed, and the second ventral segment with one instead of two tubercles.

At first sight the upper surface appears to be glabrous, but on close examination a very fine sparse pubescence becomes visible. The tenth joint is conspicuously larger than the eleventh. The tubercles are very indistinct from some directions, and are not at the extreme apex of the second segment.

The specimens from Dr. Ferguson, Mr. Goudie and I, were all taken in nests of *Ponera lutea*, and Mr. Cox took it in nests of that species and also of *Iridomyrmex rufoniger*.

Eupines exigua, King.

Mr. H. W. Cox has taken this species in a nest of *Iridomyrmex rufoniger*.

Eupines clavatula, King.

Also taken by Mr. Cox from a nest of *I. rufoniger*.

Rybaxis quadriceps, Westw.

A male specimen in the National Museum of Victoria (Howitt collection) bears a label *Bryaxis quadriceps*, and is probably that species. It is very feebly punctured, however, and the front femora are minutely dentate near the trochanters,

characters which are at variance with the original description. The epipleurae of its elytra have a narrow marginal stria, and a deep furrow slightly curved posteriorly, and continuous almost to base and apex.

Rybaxis strigicollis, Westw.

Described originally as from an ants' nest in Victoria. The species occurs also in Tasmania, but the specimens before me were taken on fence tops at dusk.

Rybaxis lunatica, King.

Five specimens of this species were sent for identification by the National Museum, of which one was marked "Out of hollow branch containing nest of *Podomyrma gratiosa*, F. P. Spry."

Rybaxis, sp.

A single specimen of this genus was taken from a nest of *Amblyopone australis* at Sheffield (Tasmania). It perhaps represents a variety of *electrica*, from which it differs in being larger (almost the size of *5-foveata*), and with slightly longer clothing. It is a female, possibly the male would prove the species to be distinct, as I have never taken an undoubted specimen of *electrica* in ants' nests, although it is the commonest species of the family in Tasmania.

Bryaxis atriventris, Westw.

Recorded originally as from ants' nests. M. Raffray regards the genus *Bryaxis* as being entirely absent from Australia, and the species previously referred to it are mostly now referred to *Rybaxis* and *Eupines*. This species, however, he placed[1] as a synonym of *Pselaphophus clavatus*, King, but in this he seems to be in error.

I have two specimens (seen by M. Raffray) that were compared, and agreed with the types of *clavatus;* King described the head of that species as having two inter-ocular elongate

1 Proc. Linn. Soc. N.S. Wales, 1900, p. 202.

foveae, becoming confluent in front. Westwood, on the other hand, described and figured the head of *atriventris* as having a single large inter-ocular fovea. As the type is probably still extant, it is desirable that its correct generic position should be recorded.

Briara basalis, King.

A specimen of this species was taken by Mr. Cox from a nest of *Iridomyrmex rufoniger*, and another from a nest of *Ponera lutea.*

Anarmoxys simplicifrons, Raffr.

A specimen of this species was taken by Mr. Cox from a nest of *Iridomyrmex rufoniger.*

Cyathiger punctatus, King.

I have a record as to a specimen of this species being taken from an ants' nest under a stone, but do not now know on what authority. The types were taken from beneath half-buried logs.

Pselaphus flavipalpis, n.sp.

♀. Reddish castaneous, tarsi and palpi flavous. Clothed with sparse and rather short but suberect straggling pale pubescence, sparser on elytra than elsewhere, apex of elytra sparsely fringed with short depressed setae. Under surface with dense whitish pubescence at base of abdomen, and on meso- and pro-sternum.

Head shorter than usual, very feebly channelled; with punctures between eyes. Antennae, for the genus, rather short, none of the joints from second to eighth distinctly longer than wide. Palpi elongate, club of apical joint rather more than one-third the length of peduncle. *Prothorax* comparatively short, with a strong transverse subbasal impression, connecting five small foveae. *Elytra* almost as long as abdomen, wider (at apex) than long, each with a sutural, a discal and a submarginal stria. Length 1½ mm.

Hab.—Queensland: Townsville, from nest of small ground ant (F. P. Dodd).

Of the species known to me comes closest to *pilosus*, but differs in being smaller, antennae shorter, with terminal joint smaller, clothing shorter, whitish, and on the elytra more conspicuously linear in arrangement. In general appearance it is also rather closer to *geminatus*, but the clothing is longer, the head is different, and the discal stria (which is strongly curved) is double only on the basal half. The head is without tubercles between the eyes, and from most directions appears to be without a channel, but at the apex the channel is suddenly deepened, so that, from some directions, there appear to be two conspicuous inter-antennal tubercles.

Pselaphus tuberculifrons, Raffr.

Only the female of this species was described by Raffray. The male differs in having the metasternum very shallowly and widely impressed, and the impression continued on to the large segment of abdomen. The Western Australian specimens before me, from Bridgetown, were from nests of *Dolichoderes scabaridus.*

Tasmanian specimens, obtained from tussocks, have the inter-ocular tubercles not quite so conspicuous, but in all other respects agree well with the Bridgetown ones.

Pselaphus geminatus, Westw.

Described originally as from an ants' nest. The only specimen I have seen is in Mr. Goudie's collection, and was taken by him at Sea Lake (Victoria) in a nest of *Ponera lutea.*

Pselaphus antipodum, Westw.

Described originally as from an ants' nest. The species may often be taken in abundance during floods in N.S. Wales and Victoria.

Curculionellus riparius, Raffr.

Taken by Mr. Cox in nests of *Ectatomma metallicum* and of *Iridomyrmex rufoniger.*

Ctenisophus.

Probably all, or at any rate most, of the species of this genus are to be taken occasionally in the nests of ants. They have not been so recorded, however, this probably being due to most of the specimens having been taken in flood debris, on fence tops at dusk, or at lights. One of the more satisfactory characters for distinguishing species of the genus is the impression on the middle of the third ventral segment of the male; but in the descriptions of most species of the genus this has not even been mentioned. Apart from this the sexes are readily distinguished by the antennae, in the male the four terminal joints forming a club, in the female the apical joint only, or the two apical, forming the club.

Ctenisophus morosus, Raffr.

I have seen but Tasmanian specimens of this species, but in Tasmania it is the most common of the genus. Specimens have been taken in flood debris, in tussocks, on fence tops at night, and in the nests of two species of ants (*Colobopsis gasseri* and *Camponotus nigriceps*). It may be readily identified by the strong transverse impression on the third abdominal segment of the male.

Ctenisophus patruelis, Raffr.

Two specimens of this species were taken in the nest of a small brownish ant, perhaps an *Iridomyrmex*.

Ctenisophus impressus, Sharp.

Described by Sharp from W. Australia, but recorded by Raffray (who had a co-type) from S. Australia and Victoria as well. Specimens before me, which appear to belong to the species, are from N.S. Wales (taken by Dr. Ferguson in the nest of a white ant, *Eutermes* sp.); Victoria (Birchip, J. C. Goudie, Ararat, H. W. Davey in a nest of small black ants rather larger than *Colobopsis gasseri*); Adelaide (from King's collection) and W. Australia (Darling Ranges, A. M. Lea, from a nest of *Termes lacteus*).

Ctenisophus inaequalis, Raffr.

Described by M. Raffray from my sending, but the name was not given to me till after its publication, when he wrote me that it was my number 609. Apparently I sent him all my specimens as I appear to have now none of 609, and cannot recognise the species in my collection. Under 609 I have a record that it was taken with white ants; but the only specimen that I now have mounted with white ants of my own taking is one that appears to belong to *impressus*, and which has the impression on the third ventral segment of the male so faint that it could practically be regarded as absent.

Ctenisophus, sp.

Dr. Ferguson has sent three specimens of a species of this genus from a nest of white ants at Narromine. They appear to be undescribed and different to all in my collection; but as they are all females, and without very distinctive features, it appears best to leave them undescribed at present.

Ctenisophus rivularis, n.sp.

♂. Pale reddish-castaneous, appendages somewhat paler. Moderately covered with pale scale-like setae, denser at apex of elytra and of the basal segments of abdomen than elsewhere.

Head with two large shallow foveae between eyes. Antennae rather long, first joint stout and slightly longer than second, second stouter and slightly longer than third, third to seventh small and subequal, eighth to eleventh combined distinctly longer than first to seventh combined, eighth slightly but distinctly longer than ninth and just perceptibly longer than tenth, eleventh elongate-elliptic, longer than ninth and tenth combined. Three apical joints of palpi each with a long thin appendage. *Prothorax* widest at about apical third, thence gently decreasing in width to base; with a large subbasal fovea open posteriorly. *Elytra* each with a distinct sutural stria and a somewhat curved discal one; punctures small but fairly distinct. *Metasternum* deeply sulcate. *Abdomen* with third segment large, and middle of under surface with a rather small and shallow round fovea. *Legs* long and thin. Length 1 mm.

♀. Differs in the antennae being shorter, with the ninth joint no longer than the eighth, the tenth stouter and longer than the ninth (but much shorter than in the male), and the eleventh somewhat shorter than in the male, but as long as the four preceding joints combined, the abdomen also is nonfoveate.

Hab.—W. Australia: Swan and Vasse Rivers (A. M. Lea).

Close to the description of *parvus* (the abdominal impression of which is not mentioned), but that species is said to have the prothorax with the sides "not dilated in the middle, so that it is not narrower at the base than in the middle." In the present species it is quite certainly narrower at the base than at the middle, and the apex is much narrower than the middle. The third abdominal segment of the male with a quite round fovea distinguished from the description of *inaequalis*, in which it is said to be suboblong. The antennae are slightly longer than in *morosus* (or at least fully as long) instead of slightly shorter as in the description of *patruelis*. (Of the latter species the abdominal impression is not mentioned.)

Three only of the numerous specimens before me are noted as from ants' nests, two of these (sexes) being from a nest of *Crematogaster laeviceps*.

Somatipion globulifer, Schfs.

Messrs. Goudie and Davey have taken numerous specimens of a species from nests of *Iridomyrmex nitidus*, which certainly belongs to *Somatipion*, and probably to *globulifer*. The genus[1] is readily identified amongst the Australian *Pselaphidae* by its antennae and abdomen. The former are eleven jointed with a large globular terminal joint, whilst the abdomen has a very decided median longitudinal impression on its upper surface.

The specimens before me have the head rather longer than in the figure, the abdomen less inflated in the female, and still less inflated in the male. These specimens range from 2½ to 4 mm. in length, the indicator at the side of the figure is 3 mm. in length. The pubescence on some specimens is rather looser than on others, but this is probably due to treatment.

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1 Raffray's beautiful figure renders the genus easy of identification. Reference to this figure (Revue d' Entomologie, 1890, pl. iii., fig. 31) is omitted from his recent generic revision of the family.

There appear to be no special masculine features. The male is smaller, usually much smaller, than the female, somewhat thinner, with the fourth abdominal segment more noticeably incurved at apex, and the subbasal impression of the prothorax somewhat closer to the base.

Tmesiphorus ponerae, n.sp.

♂. Of a rather dark reddish-castaneous; elytra and metasternum somewhat paler, palpi somewhat flavous. Clothed with pale pubescence, sparser on head and prothorax, and denser at apex of elytra and under surface of abdomen, than elsewhere; but under surface of head with a distinct fascicle behind each eye.

Head with dense distinct punctures; with two small shallow foveae between eyes, base feebly impressed, the impression very feebly continued to between the antennae, where it suddenly deepens. Antennae fairly stout, extending to middle coxae, first joint distinctly longer than second, second slightly but distinctly shorter than third, and slightly longer than fourth, fourth to eighth short and subequal, ninth and tenth larger and wider, their combined length about equal to that of eleventh, which is ovate. Palpi with the antepenultimate joint setose at apex, the subapical with a thin appendage, and the apical produced at apex and dilated on one side of base. *Prothorax* slightly longer than wide, strongly convex; punctures as on head; with a small round, subbasal fovea, and a larger and somewhat irregular one on each side near base. *Elytra* not as long as greatest width and shorter than abdomen; punctures smaller than on prothorax, each with a strong sutural stria, becoming deep at base, another still deeper and larger at base, and strongly impressed to slightly beyond the middle of disc, where it rather abruptly terminates. *Abdomen* with a narrow carina towards each side of first segment on upper surface, and continued on to basal third of second; under surface with a large median fovea common to two segments, but deeper posteriorly. *Metasternum* rather deeply impressed posteriorly. *Legs* long and thin; front tibiae curved and widened in middle. Length $2\frac{1}{3}$ mm.

♀. Differs in being somewhat thinner, antennae rather shorter and thinner, and abdomen nonfoveate.

Hab.—W. Australia: Bridgetown and Donnybrook—in nests of *Ponera lutea* (A. M. Lea).

Of rather more slender build than *formicinus* and with ventral impressions different. In the male of *formicinus* the second segment is shallowly foveate in the middle of the apex, and the third feebly impressed in the middle, the impression shallower than on the second. In the present species the impression on the second is wider and shallower, whilst that on the third is decidedly deeper than that on the second, from some directions appearing as a round deep fovea. From the sides the basal joint of the antennae appears to be fully twice as long as the second, but from above the second appears to be about two-thirds its length.

Tmesiphorus curvipes, n.sp.

♂. Of a rather bright reddish-castaneous, tarsi and palpi somewhat paler. Clothed with short depressed and rather sparse pubescence, but with a small fascicle on each side of under surface of head behind each eye.

Head with dense, strong punctures; with two deep and fairly large foveae between eyes, with a feeble basal impression. Antennae fairly stout, almost extending to hind coxae, first joint cylindrical, about as long as three following combined, second slightly stouter, but no longer than third, third slightly longer than fourth, fourth to eighth short and subequal, ninth about twice as long, and twice as wide as eighth, and slightly narrower but no shorter than tenth, the two combined slightly longer than eleventh, which is irregularly ovate. *Prothorax* slightly longer than wide, sides somewhat angularly dilated at apical third, thence strongly diminishing in width to apex, and feebly to base, with a small sub-basal suboblong fovea, and a larger irregular one on each side near base; punctures as on head. *Elytra* distinctly wider than long, much shorter than abdomen; punctures sparser than on prothorax but clearly defined; each with a distinct sutural stria, and a strong impression between suture and shoulder. *Abdomen* with a narrow

carina towards each side of upper surface, and rather longer but less distinct than in preceding species; under surface with a feeble impression in middle of second segment, and a similar one on third. *Metasternum* strongly impressed along middle. *Legs* long and thin; front tibiae strongly curved and somewhat thickened in middle, the middle pair moderately curved near apex, the hind pair almost straight. Length 2 mm.

Hab.—Victoria: Ocean Grove—in a nest of *Iridomyrmex nitidus* (H. W. Davey).

The head has a peculiar appearance, as of having a spine over the base of each antenna, when viewed from the side, as in *formicinus*, but it differs from that species in being smaller, with cephalic foveae more, and the abdominal ones less, pronounced and the clothing shorter and sparser. The size and clothing are much as in *macleayi*, but that species has the tenth joint of antennae very distinctly shorter than the ninth. The palpi are much as in the preceding species, but the antennae (especially the basal joint), abdominal impressions, clothing and shape are different.

Each elytron at the base has a strong impression, its inner wall from some directions appearing carinated posteriorly, but the impression terminates before the middle, and could scarcely be regarded as a stria. The type has been described as a male, as its ventral impressions, although faint, are quite distinct.

Tmesiphorus brevicornis, n.sp.

Dark reddish castaneous, elytra club and tarsi paler, palpi still paler. With very short pale pubescence.

Head transverse; with two small inter-ocular foveae; with a deep impression between antennary ridges; with a short spine behind each eye on the side; densely and rather coarsely punctate. *Antennae* rather short and stout, scarcely extending to base of prothorax, first joint from above apparently slightly shorter than second, but really about twice as long, second to eighth transverse, ninth considerably longer and wider, but feebly transverse, tenth the width of but shorter than ninth, eleventh briefly ovate. *Prothorax* strongly convex, slightly

longer than wide, sides moderately rounded and widest almost in exact middle; with three subbasal foveae, of which the lateral ones are rather large, and the median one rather small, but still conspicuous; punctures almost as on head. *Elytra* lightly transverse, shoulders strongly the sides moderately rounded; dorsal striae deep and wide on basal half, subsutural striae wide at base; with small dense punctures. *Abdomen* scarcely wider but considerably longer than elytra; second segment with three strong ridges, of which the median one is somewhat shorter and less pronounced than the others, third segment with a fairly strong ridge towards each side, but scarcely ridged along middle; lower surface flattened along middle. *Metasternum* flattened in middle, but excavated posteriorly. *Legs* moderately long; four front tibiae obtusely spurred at apex. Length $2\frac{3}{4}$ mm.

Hab.—Queensland: Townsville, from a nest of white ants (H. J. Carter from F. P. Dodd).

The dorsal ridges of abdomen and post ocular spines associate this species with *termitophila*, which, however, is a much larger and shining species, with very different antennae, etc. In size and general appearance it is like *ponerae*, but the head antennae and abdomen are different.

The space between the dorsal and subsutural striae on the basal half of each elytron appears to be obtusely ridged. The second and third ventral segments appear somewhat flattened but not foveate, and as I can see no distinctly masculine features the type is probably a female.

Tmesiphorus formicinus, Macl.

I have seen specimens of this species from the nests of *Ponera lutea*, from New South Wales, Victoria and West Australia. It was described by Macleay as from the nests of *Ectatomma socialis*, but his description of that ant reads as if it was founded on *P. lutea*, instead of on an *Ectatomma*.

Tmesiphorus termitophilus, Raffr.

Occurs in nests of *Coptotermes raffrayi*.

Tmesiphorus macleayii, King.

One of the types originally recorded as "being found under bark, in company with . . . some small ants."

Palimbolus, sp.

A single female of this genius was taken in the Illawarra district by Mr. Cox from a nest of *Iridomyrmex rufoniger;* but as it has no very distinctive features (such as are always present in males of the genus) it is best left undescribed at present. No species of the genus has hitherto been recorded as occurring in ants nests.

Gerallus palpalis, King.

Taken by Mr. Cox from a nest of *Ectatomma metallicum.*

Tyromorphus humeralis, Westw.

Described originally as from an ants' nest.

Tyromorphus spinosus, Westw.

Described originally as from an ants' nest.

Tyromorphus formicarius, n.sp.

♂. Reddish castaneous, suture and apex of elytra and knees somewhat darker. Clothed with short pale pubescence, appearing almost like scales on head and prothorax, on elytra more distinct, and denser on abdomen (both surfaces) than elsewhere.

Head rather wide; with dense, shallow punctures; with a rather small fovea on each side of middle, antennary ridges separated by a deep and somewhat oval impression. Antennae passing middle coxae, first joint almost as long as second and third combined, second transverse, third thinner and longer than second or fourth, fourth to eighth transverse and of almost even width, but fifth slightly larger and eighth shorter than the others, ninth about twice as long and almost twice as wide as eighth, tenth shorter and slightly narrower than ninth, eleventh briefly ovate (almost globular) and distinctly shorter

than ninth and tenth combined. *Prothorax* about as long as wide, widest at apical third, thence strongly narrowed to apex and moderately to base, base slightly wider than apex; with three small foveae near base, one in the middle and one on each side; punctures as on head. *Elytra* slightly wider than long, with a distinct sutural stria, and each side of base with remnant of a discal one; with numerous distinct punctures. *Abdomen* distinctly longer than elytra; under surface with a feeble median impression; fourth segment incurved to middle, fifth very strongly incurved to and scarcely traceable across middle. *Metasternum* strongly impressed in middle apex. *Legs* rather long and thin; tibiae feebly bisinuate on lower surface, front pair obtusely mucronate at apex. Length $2\frac{1}{2}$ mm.

Hab.—N.S. Wales: Sydney, in nest of *Iridomyrmex rufoniger* (H. W. Cox).

The palpi are smaller than in other species of *Tyromorphus*, and the terminal joint is thinner, but as in other respects it agrees with the genus, and I have but a single specimen under examination, it does not appear desirable to propose a new genus for its reception. The club of the antennae, however, is very different to that of any other described species. From the side the base of each antenna appears to be set beneath a curved spine. The head and prothorax are subopaque.

Articerus.

All the species of this genus occur in ants or termites' nests, generally but few specimens occur in individual nests, but those of several species of ants are seldom without them. Two species *breviceps*, King and *regius* King,[1] were overlooked by Schaufuss and Raffray; also *sharpi* Masters, a name used to replace *tumidus* Sharp, *tumidus* having been previously used by Westwood, but the species described by both Westwood and Sharp under the name *tumidus* appear to be identical.

Articerus cultripes, Raffr.

Occurs in nests of *Iridomyrmex rufoniger* and of a species of *Colobopsis*.

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1 Trans. Ent. Soc. N.S. Wales, vol. ii., pp. 55-56.

Articerus hamatipes, Raffr.

Occurs in nests of *Iridomyrmex glaber.*

Articerus regius, King.

In the original description of this species the abdominal fovea is not mentioned. Mr. Masters has sent two specimens for examination both males and from Liverpool, one of which is probably the cotype mentioned as being deposited in the Macleay Museum.

The abdominal fovea is confined to the basal segment, and is bounded on each side of the middle by an oblique ridge, of which the apices are separated fully twice the width of the bases. The front femora are larger, and the middle femora much larger, than the head.

Articerus breviceps, King.

Mr. Masters has sent for examination a co-type of this species, probably a female, and unfortunately with both antennae missing. In the original description the abdomen is not even mentioned; its fovea is, for the genus, comparatively shallow, somewhat encroaching on middle of second segment, and with a wide flattened oblique ridge on each side of the middle. The prothoracic fovea is unusually large, the punctures on each side of and behind it coarse, but in front much finer. The base of the head has a distinct longitudinal impression. The tibiae are strongly (but, for the genus, moderately) inflated towards the apex.

Articerus aurifluus, Schfs. (Fig. 30).

Mr. H. H. D. Griffith has sent from Adelaide[1] nine specimens that appear to belong to this species. They have the antennae, prothorax and abdomen (the clothing at the sides is remarkable) as described, but the head is more rounded in front than triangular, although from some directions it appears feebly triangular.

The hind tibiae of the male are narrow at the base, then suddenly inflated and subparallel to near the apex, where they

1 The type was recorded from Melbourne.

are obliquely truncated. Its metasternum is strongly convex along the middle. The length varies from $1\frac{1}{2}$ to $1\frac{3}{4}$ mm.

The ant in whose company it is taken appears to be a species of *Colobopsis*. Mr. Davey has also sent the species from the nest of a small black ant at Geelong (Victoria).

Articerus brevipes, Sharp.

Described from a single female and as probably from Champion Bay. Two females from N.W. Australia in the Macleay Museum appear to agree with the description.

Articerus curvicornis, Westw.

The late Rev. R. L. King stated that he had frequently captured this species at Liverpool (N.S. Wales) "in the nest of the small black ant." It appears to be the commonest species of the genus, and occurs in Tasmania as well as N.S. Wales and Victoria, and in the nests of several species of ants, including *Colobopsis gasseri*, *Iridomyrmex nitidus* and *I. gracilis*.

Articerus bipartitus, Raffr.

In nests of two species of ants, *Crematogaster*, sp., and *Colobopsis?*, sp. Also in nests of a species of white ant.

Articerus dilaticornis, Westw.

Mr. Goudie has sent a male from a nest of *Iridomyrmex nitidus* that probably belongs to this species. It agrees well with the description; but differs from the figure in having the eyes less prominent, prothorax rather wider across apex, and abdominal fovea not rounded behind but subtriangular—much as in *mastersi*.

Articerus gibbulus, Sharp.

Occurs in nests of *Crematogaster laeviceps* and of *Iridomyrmex nitidus*.

Articerus fortnumi, Hope.
bostocki, Pasc.
odewahni, Pasc.

Appears to be a common species in nests of *Crematogaster laeviceps* in S. Australia. The synonymy is according to Dr. Schaufuss.

Articerus tumidus, Westw.
tumidus, Sharp
sharpi, Masters.

There appears to be no doubt, but that the same species was described under the name of *tumidus* by Westwood and Sharp, and there is therefore no need for the name *sharpi* proposed as a substitute for *tumidus*, Sharp.

Articerus angusticollis, Westw.

Recorded originally as from ants' nests.

Articerus setipes, Westw.

Recorded originally as from ants' nests.

Articerus asper, Blackb.

Recorded as taken from flood debris. It is curious that this is the only species that has been so recorded, as nests must frequently be flooded out, and although I have seen thousands of *Pselaphidae* in flood debris, I have never yet taken an *Articerus* in it.

The following species, although not so recorded, are certain to occur in the nests of ants or termites.

A. Deyrollei, Sharp.
A. Duboulayi, Waterh.
A. falcatus, Raffr.
A. foveicollis, Raffr.
A. Kingius, Sharp.
A. nitidicollis, Raffr.
A. Pascoeus, Sharp.
A. Selysi, Schfs.
A. spinifer, Sharp.
A. Westwoodi, Sharp.

Articerus raffrayi, n.sp. (Figs. 32, 33.)

♂. Reddish-castaneous, greater portion of each elytron somewhat paler than elsewhere. With short depressed setae, resembling scales on head prothorax and parts of elytra, abdomen with sparse erect setae, but fasciculate on each side of base.

Head short, flat, densely punctate and without longitudinal impression. Antennae short wide and flat, about as long as head, narrow at base, then strongly inflated, and then feebly diminishing in width to apex, widest portion with a feeble impression in middle. *Prothorax* widest at apical third, where the width is almost twice as great as the length, with a feeble medio-basal impression, punctures as on head. *Elytra* with dense punctures, rather sparser on disc than elsewhere, sutural stria distinct. *Abdomen* with basal fovea strongly transverse, and not encroaching on second segment, its sides parallel, near each side with a feebly elevated ridge almost parallel with the margin and behind the fovea becoming narrower and more distinct; under surface largely excavated, each side of middle of fourth segment with a small acute tooth, similar but smaller teeth on first, middle of fifth with a loose facicle. Metasternum obtusely ridged along middle, the ridge terminating in a feeble tooth. *Femora* fairly stout; tibiae inflated towards apex, the middle pair strongly mucronate at apex. Length $1\frac{3}{4}$—2 mm.

♀. Differs in having under surface of abdomen simple, metasternum edentate, less convex along middle and the middle tibiae not mucronate.

Hab.—N.W. Australia (Macleay Museum).

Seen from behind and the side each antenna appears to be placed in the middle of a semicircular emargination, to be thin with the apical third suddenly thickened. The apex itself is somewhat oval in outline. From some directions the sides of the prothorax appear to be obtusely produced at the apical third, with the produced portion obtusely serrated.

Articerus dentipes, n.sp. (Figs. 31, 34, 35.)

♂. Reddish castaneous, greater portion of each elytron somewhat paler. Clothed with fine depressed setae, but becoming longer and denser at apex of elytra; abdomen with fine more or less erect setae, and fasciculate on each side of base.

Head short, flat, densely punctate and without longitudinal impression. Antennae slightly longer than head, wide and flat, base narrow, then strongly inflated to middle, and thence very feebly diminishing in width to apex. *Prothorax* about

once and one-third as wide as long, sides very feebly diminishing in width from apex to base, with a shallow, longitudinal medio-basal impression, punctures as on head. *Elytra* with dense punctures, rather sparser on disc than elsewhere; sutural stria feeble. *Abdomen* with a large transverse basal fovea, somewhat produced on each side, each side with a feebly elevated oblique ridge; under surface somewhat excavated. *Metasternum* flattened along middle, but with a small apical tooth. *Femora* stout, the middle pair especially; middle trochanters each produced into the form of a strong curved tooth, about half the length of the femur; tibiae short, middle pair strongly inflated, front pair mucronate at apex. Length $1\frac{1}{3}$ mm.

Hab.—Victoria: Birchip, two males from an ants' nest (J. C. Goudie).

Rather smaller than *curvicornis*, antennae wider, etc. In many respects close to the description of *pascoeus*, but with the prothorax decidedly transverse instead of "quite as long as broad." The middle legs are much as in the description of *tumidus*, but Sharp describes the prothorax of that species as "about as long as broad"; its metasternum is also not ciliated in the middle, but shining and with a small apical process. The abdominal fovea is also large instead of small. From the species identified as *brevipes* it differs in being less compact, in the antennae being less flattened, the elytral clothing longer and the abdominal fovea not quite the same. It comes very close to the description and figure of *setipes*, but has a distinct sutural stria, whereas that species is twice stated to be without such, and is also so figured. The length also is much less than a line. The antennae from the sides are as in the preceding species but from above they are seen to be longer and thinner, with the greater length due principally to a longer basal stem.

Articerus irregularis, n.sp. (Figs. 36, 37.)

♂. Colour and clothing as described in *raffrayi*, except that the abdomen has fine depressed setae in addition to the erect ones, and that the basal fascicles are less conspicuous.

Head rather short and flat, with a scarcely traceable median impression. Antennae short wide and flat, base narrow, then

strongly inflated to middle, and then rather strongly narrowed to apex; a distinct longitudinal impression in middle of both surfaces. *Prothorax* about once and one-third as wide as long, sides rounded in front, and feebly diminishing in width to base, with a shallow but distinct medio-basal impression; punctures as on head. *Elytra* with dense punctures, rather less crowded on disc than elsewhere; sutural stria distinct. *Abdomen* with fovea strongly transverse, each side at base with a feebly raised oblique ridge, each side at apex continued as a strong oblique impression; under surface with a large and almost circular fovea. Metasternum almost flat along middle, edentate at apex. *Femora*, for the genus, rather thin; tibiae inflated at apex, the middle pair strongly mucronate at apex. Length $1\frac{3}{4}$ mm.

Hab.—Victoria: Forrest, a single male from the nest of a small black ant in a log (H. W. Davey).

Each antenna is suddenly inflated about the middle, but the inflation is not uniform on both sides, being slightly nearer to the base on the inner than the outer side, from some directions the inner inflation appears almost tuberculate. From the side each appears to have the basal half thin (the thinnest portion being just before the expanded part) with the apical half strongly inflated. The apex itself is oval. The oblique continuations of the abdominal fovea are very distinct.

Articerus excavipectus, n.sp.

♂. Colour and clothing much as in *raffrayi*.

Head rather wide and almost flat, not depressed along middle, densely punctate. Antennae wide and flat, slightly shorter than head, strongly inflated to about middle, and thence almost parallel-sided, without median impression. *Prothorax* about once and one-fourth as wide as long, widest near apex, thence feebly diminishing in width to base; punctures as on head, with a fairly large medio-basal fovea. *Elytra* with dense punctures, becoming sparser on disc, and with on each a small almost impunctate spot at about the middle at the apical third; sutural stria rather feeble. *Abdomen* with basal fovea very large, and posteriorly regularly decreasing in depth, instead of being

convex in middle, sides distinctly narrower than behind the fovea, each side with a feebly raised and indistinct ridge; under surface less excavated than usual, but the excavation joining on to a very large one on metasternum. Hind *coxae* each with a strong triangular tooth at right angles to the general level; femora fairly stout; hind tibiae inflated towards apex, the front pair less and the middle pair still less noticeably so. Length $1\frac{3}{4}$ mm.

♀. Differs in having the abdomen gently convex on the under surface, the apex of the metasternum very feebly impressed, and the hind coxae unarmed.

Hab.—Victoria: Birchip (J. C. Goudie); S. Australia (Macleay Museum).

The antennae are very wide as in *raffrayi*, but not of the same shape, and not impressed on the upper surface; the latter character will also distinguish it from *aurifluus*. *Asper* is described as having the prothorax nonfoveate.

Seen from the sides each antenna appears to have the basal third thin, with the rest swollen, rather more noticeably on the under than the upper surface. From some directions the sides of the prothorax almost appear to be ridged. The impunctate spot on each elytron is distinct on one specimen, fairly distinct on another, but practically absent from a third. The large spurs on the hind coxae of the male appear at first to be part of the metasternum. The apical segments of the male are so strongly drawn inwards that the pygidium appears to be in the exact middle of the under surface of the abdomen.

Articerus Mastersi, n.sp.

♀. Colour and clothing much as in *Raffrayi*.

Head wide, flat and densely punctate, without median impression. *Antennae* slightly longer than head, wide and flat, base narrow, then strongly inflated to middle, and thence feebly diminishing to apex, with a distinct but rather shallow depression in middle. *Prothorax* about once and one-third as wide as long, sides almost parallel, with a large but rather shallow medio-basal fovea; punctures as on head. *Elytra* with dense punctures, becoming sparser on disc; sutural stria

distinct. *Abdomen* with basal fovea large and encroaching in the form of a wide triangle on to middle of second segment, each side of base with a wide flat feebly elevated oblique ridge. Metasternum gently convex in middle. *Femora* moderately stout; tibiae inflated towards apex. Length $1\frac{1}{3}$ mm.

Hab.—S. Australia (type in Macleay Museum).

The abdominal fovea is of very different shape to that of the species I suppose to be *brevipes*, and the metasternum, although shining, is not highly polished along the middle as in that species; the antennae also are different. In size and general appearance, however, the two species are very similar. The antennae and abdominal fovea are somewhat as in *dilaticornis*, but that species is described and figured as having the prothorax longer than wide. The antennae, both from above and the sides, have the outlines as in *dentipes*, but are distinctly impressed in the middle. One of the specimens was labelled as *setipes*, but it differs from the description of that species in having a distinct sutural stria, and the tibiae without long setae towards the apex; the latter character may be sexual but not the former. Its abdominal fovea also is not as figured in *setipes*.

Articerus constricticornis, n.sp. (Figs. 38, 39.)

♀. Dark reddish castaneous, greater portion of each elytron somewhat paler. Clothed with short, depressed setae, except on abdomen where they are sparser and more erect, each side of base also with a thin elongated ridge or depressed fascicle, middle of metasternum with a line of golden setae.

Head (for the genus) rather long, flat, densely punctate, and without median impression. *Antennae* moderately wide, somewhat curved, the length of, or slightly longer than, head. *Prothorax* widest near apex, where the width is about once and one-half the length, sides gently but distinctly decreasing to base; medio-basal impression rather small and feeble; punctures as on head. *Elytra* with dense punctures, becoming sparser at inner disc; sutural stria distinct. *Abdomen* with basal fovea strongly transverse and deep, near each side with a wide very feebly elevated oblique ridge, sides with margins

continued to beyond the middle. Metasternum gently convex along middle. *Femora* not very stout; tibiae strongly inflated towards apex. Length 2 (vix) mm.

Hab.—N.S. Wales: Murrurundi (type in Macleay Museum).

Readily distinguished from all other species known to me by the shape of the antennae as seen from the side, each there appears rather stouter than is usual towards the base, in the species having wide antennae, in the middle it is strongly constricted, with the apex but little wider than the base. From above each appears to have the inner outline straight (except for a slight projection at the basal third), but the outer side dilated to beyond the middle and then straight to apex. The middle, from some directions, appears largely scooped out. The convex portion of the upper surface of the abdomen is almost circular in outline.

Articerus constrictiventris, n.sp. (Fig. 40.)

♀. Reddish castaneous. Clothed with short depressed setae, and with sparse suberect ones; abdomen with longer suberect ones only and fasciculate on each side of base.

Head rather wide, flat and densely punctate, without median impression. Antennae long and thin, apical fourth strongly, although not suddenly, inflated, base feebly curved, apex circular in outline. *Prothorax* about once and one-half as wide as long, base distinctly rounded and wider than apex, sides gently rounded; with a large but rather shallow medio-basal impression; punctures very distinctly sparser than on head. *Elytra* with smaller punctures than usual, especially on apical half, towards base becoming subseriate in arrangement; sutural stria distinct. *Abdomen* with basal fovea large and deep, with its walls suddenly and strongly constricted in middle so that it appears as if divided into two. Metasternum gently convex along middle. *Legs* long and thin. Length $1\frac{3}{4}$—2 mm.

Hab.—Victoria: Wangaratta, two females from an ants' nest under a stone (A. M. Lea).

In many respects close to description of *spinifer*, but antennae not twisted at apex, and apex of body with sparse and rather short setae instead of numerous elongate ones. It is also

close to *nitidicollis*, but head not longitudinally foveate, antennae hardly more than once and one-half the length of the head,[1] prothorax not very shiny, with a large shallow circular fovea, certainly not "transversim late impressus . . . fovea antebasali minuta," and without a basal carina. Other characters of the metasternum and abdomen with which the specimens disagree are probably sexual.

The head from certain directions appears to be supplied with a very narrow, shining, median carina. The prothorax wider at the base than near apex, and with different punctures to those on head are very distinctive features.

Articerus femoralis, n.sp. (Fig. 41.)

♂. Colour and clothing much as in *raffrayi*.

Head wide, flat and densely punctate; with a very feeble but somewhat shining median depression. Antennae slightly longer than head, rather thin but gently increasing in width to apex, which is circular in outline. *Prothorax* not much wider than long, front angles rounded, basal two-thirds parallel-sided; with a fairly large medio-basal impression; punctures as on head. *Elytra* with fairly dense punctures, becoming denser at base; sutural stria distinct. *Abdomen* with basal fovea large and deep, its hind margin semicircularly encroaching on the second segment, the semicircle bounded on each side by a distinct, but small tubercle, itself being the apex of a feeble oblique sublateral ridge; under surface largely excavated but not foveate. Metasternum ridged along middle, with two small apical teeth. *Femora* stout, hind pair with a strong triangular subapical tooth; tibiae inflated. Length $1\frac{1}{2}$ mm.

♀. Differs in having the under surface of abdomen and the metasternum on an almost even plane, with the latter not armed at apex, and the femora unarmed.

Hab.—N.S. Wales: Sydney, in nest of *Iridomyrmex rufoniger* (H. W. Cox), in nest of a small ant[2] (E. W. Ferguson).

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1. Although Raffray describes the antennae as twice as long as head, he does not so figure them, the proportions being as $8\frac{1}{2}$ to 13 millimetres.

2. Perhaps *I. rufoniger*, but the specimen sent by Dr. Ferguson is very pale and somewhat distorted.

Antennae considerably thinner than in *curvicornis*, when viewed from the sides almost straight, and, when cut across in any part of their length, circular in section; the abdominal tubercles also are not as in that species. The general appearance is much like *hamatipes*, and the antennae are very similar, but the abdominal fovea and legs are different. *Bipartitus* is similar in many respects, but also has abdomen and legs different and much more clothing.

Articerus cylindricornis, n.sp. (Figs. 8, 42.)

♂. Reddish-castaneous, greater portion of each elytron somewhat paler. Head and prothorax with short depressed setae, resembling scales, elytra with longer but still depressed setae, condensed into a feeble fascicle at the middle of the apex of each; abdomen with sparse suberect setae, and with a long loose fascicle on each side of base; with a ridge of setae along middle of metasternum.

Head about twice as long as wide, without median impression; eyes less prominent than usual. Antennae cylindrical, not much longer than head, base narrow, apex circular in outline, surface with numerous small granules. *Prothorax* not much wider than long, front angles strongly rounded, basal two-thirds almost parallel-sided; medio-basal impression absent or extremely feeble; punctures as on head. *Elytra* with dense punctures, becoming sparser on disc; sutural stria distinct. *Abdomen* with basal fovea large and strongly continued hindwards, internally at base rather suddenly deepened, then towards each side with a feeble oblique ridge; under surface largely excavated but not foveate, base strigose towards sides. *Metasternum* obtusely ridged along middle, with two small apical teeth. *Trochanters* minutely dentate; femora rather thin; tibiae flattened, front pair feebly dentate at about apical third, middle pair strongly mucronate at apex. Length $2\frac{1}{4}$ mm.

♀. Differs from male in having under surface of abdomen evenly convex, trochanters not dentate, front tibiae narrower and not dentate and middle pair not mucronate.

Hab.—Victoria: Sea Lake and Birchip (J. C. Goudie), Portland (H. W. Davey), at all three places in nests of *Iridomyrmex nitidus*; N.S. Wales: Gunning (Macleay Museum).

Some time ago[1] I doubtfully identified this species as *regius*. It differs, however, from that species (of which I have recently seen virtually a co-type) in being smaller, the head shorter and the abdominal fovea very different. Seen from the sides the antennae are feebly curved, narrow at the extreme base, but elsewhere of even width, except that the apex is feebly dilated. The median portion of the abdominal fovea is distinctly longer than wide. There are numerous specimens before me, and all the males, as in the males of *curvicornis*, each have a seta projecting from the mouth.

Clavigeropsis.[2]

This genus is recorded as monotypic in Raffray's recent generic revision of the *Pselaphidae*.[3] It belongs to the *Clavigerides*, and has the antennae six-jointed, but the basal joint small and normally concealed, so that they appear to be but five-jointed. The type of the genus (*formicarius*, Raffr.) was from Abyssinia, and an excellent figure of it is given in Revue d' Entomologie.[4] I have now to record the genus from a single specimen taken in an ants' nest in New South Wales.

Clavigeropsis australiae, n.sp. (Fig. 9.)

Reddish-castaneous. With sparse golden setae on upper surface; but becoming dense at sides of base of abdomen; metasternum with fairly dense setae along middle.

Head slightly longer than wide, densely punctate. Antennae about as long as head, two basal joints short, the first quite concealed from above, third subtriangular, fourth slightly wider and shorter, fifth wider and slightly shorter than fourth, sixth truncate, and slightly longer than fourth and fifth combined. *Prothorax* about as long as wide, sides rounded near apex, thence almost parallel to base, with a wide and rather shallow median fovea, connected by a very indistinct median line with apex; punctures as on head. *Elytra* about as long as wide, shoulders

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1 Proc. Roy. Soc. Victoria, 1905, p. 376.
2 Raffray, Rev. d' Ent., 1882, p. 3.
3 In Wytsman's Genera Insectorum.
4 1890, pl. iii., fig. 28.

round, sides dilated to near apex, hind angles gently rounded; each with a distinct sutural stria, a fine but moderal distinct discal one, and near base very faint traces of others; with sparse indistinct punctures. *Abdomen* slightly longer than elytra, base transversely strongly impressed, thence regularly and strongly convex, sides of depression strongly margined, the convex part with finer margins; under surface with basal segment short, its middle subcarinated, second and third fairly long and of equal length, fourth and fifth strongly incurved to, and narrow across middle. *Metasternum* strongly convex. *Legs* rather short; femora not very stout; tibiae rather strongly inflated to apex; tarsi thin. Length 1½ mm.

Hab.—N.S. Wales: Wollongong—in a nest of ants (A. M. Lea).

From some directions the base of the elytra appears to have numerous fine striae; whilst from others the elytra appear to be very finely strigose throughout. From the side the abdomen appears almost globular. The type appears to be a female.

PAUSSIDAE.

All the species of this family recorded from Australia are here noted, as although but few of them have been actually taken from ants' nests, it is practically certain that they all do resort to the nests of ants or termites. Nearly all the species are extremely rare, and many, so far, have only been taken at lights.

Arthropterus brevis, Westw.

I have taken this species in a nest of *Ectatomma metallicum*, in the spongy bark of a species of Eucalyptus near Sydney, and under stones and loose bark of living trees.

Arthropterus nigricornis, Macl.?

Two specimens (from Narromine in N.S. Wales and Cunnamulla in Queensland) probably belong to this species; they are, however, larger (11½ and 12 mm. respectively) than the type (5 lines). The dark antennae are opaque (except along the middle), and densely covered with minute granules. The hind

tibiae are about three times as long as wide, instead of only twice as long as wide, or even not much longer than wide (as in most species of the genus). The disc of the prothorax, as well as of the elytra, is clothed with brownish suberect setae.

Arthropterus Westwoodi, Macl.

Two specimens from Gayndah were received as co-types of this species. They have the sides of the elytra at the base with clothing as on the sides of the prothorax, but scattered all over the elytra are some exceedingly fine setae, that readily escape observation, even from the sides; especially if, as is usually the case, they are a trifle greasy or dusty.

Arthropterus angulatus, Macl.

A co-type of this species has elytral clothing as described for the above species, to which it is remarkably close.

Mr. Aug. Simson has taken several specimens of the species in ants' nests at Bowen.

Arthropterus subcylindricus, Macl.

Two specimens *in cop.* were taken under a stone at Queanbeyan, close to a nest of ants; and another pair under a stone at Millthorpe, also not far from a nest of ants.

Arthropterus neglectus, n.sp.

Dark reddish-castaneous, margins suture and appendages (tarsi excepted) somewhat paler; head black. With very short and very sparse setae, except on sides and pygidium, where they are fairly numerous; sides also with a few short hairs.

Head with dense irregular punctures; sides subtuberculate behind eyes. Antennae with more numerous punctures along sides, and paler and less polished than along middle, third to tenth joints each about five or six times as wide as long, eleventh almost as long as three preceding combined. *Prothorax* about two-thirds as long as greatest width, which is near apex, sides thence strongly rounded to apex itself, and feebly diminishing to base; margins slightly upturned, more

noticeably about base than elsewhere; median line narrow and short, but distinct; with fairly dense, irregular punctures. *Elytra* about four times as long as prothorax, and about base with somewhat smaller and sparser punctures, becoming much smaller posteriorly. Hind *tibiae* more than three times as long as their greatest width. Length 12—$12\frac{3}{4}$, width $4\frac{1}{2}$—$4\frac{3}{4}$ mm.

Hab.—N.S. Wales: Murrumbidgee (Macleay Museum), Wagga Wagga (R. Helms); Victoria: Mallee (H. W. Davey).

The largest of the genus known to me, although a trifle smaller than the length (seven lines) given for *wilsoni;* under which name I received a specimen from the Macleay Museum.[1] It differs, however, from that species in having the prothorax distinctly transverse; instead of subquadrate,[2] and with a short but distinct median line. Its head also is decidedly black. The hind tibiae are narrower than in most species of the genus, as is the case also with *wilsoni*, but the species I have identified as *nigricornis*, although otherwise very different, agrees with it in this respect, and the hind tibiae of *quadricollis* are also so figured.[3]

The third to tenth joints combined are about twice and one-half as long as wide. The scutellum when fully exposed is seen to be transversely impressed at the base, but in this, and, in fact, in most, if not all, species of the genus, it is liable to be partially covered by the prothorax, so that it is of little use to mention it in descriptions.

Arthropterus latus, n.sp.

Black, or almost black, lateral margins of prothorax, suture and appendages reddish-castaneous. Discs of prothorax and elytra quite glabrous, the sides and pygidium with short dense setae, sides of elytra with a few short hairs.

Head with moderately dense but rather small and irregular punctures; sides behind eyes scarcely tuberculate. Antennae

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1 And it appears to be the species several times referred to as *wilsoni* by Macleay,

2 In Westwood's figure in Thes. Ent. Oxon., the prothorax by measurement is actually a trifle longer than wide.

3 Westwood's figure of *quadricollis* would do very well for this species except for the antennae, and inter-ocular impressions.

rather darker and less punctate along middle than on sides, third to tenth joints each about eight times as wide as long, apical joint slightly longer than three preceding combined. *Prothorax* scarcely two-thirds as long as greatest width, sides strongly rounded on apical half and decidedly oblique on basal half, sides feebly raised and thickened, median line very feeble; with fairly numerous but small punctures about apex and apical sides, but elsewhere almost or quite impunctate. *Elytra* wide, not three times as long as prothorax, with numerous small punctures, becoming extremely minute posteriorly. Hind *tibiae* about once and one-half as long as their greatest width. Length 10, width 4 mm.

Hab.—N.S. Wales: Sydney (A. J. Coates).

Comparatively wider than any other described species of the genus. The prothorax is considerably wider than in *brevis*, apical joint of antennae longer, and the whole insect bulkier; in *brevis* the extreme width of the prothorax appears to be scarcely, if at all, greater than the extreme length, in the present species it is about once and one-half its length. The third to tenth joints combined are rather more than once and one-half as long as wide. The disc of the prothorax appears to be extremely feebly corrugated (as in many *Carabidae*), and is almost impunctate.

There are several other species before me that are possibly undescribed, but as Macleay usually omitted to describe the comparative width of the hind tibiae I do not feel justified in describing them till able to examine his types.

The other recorded species are:—

A. adelaidae, Macl.
A. angulicornis, Macl.
A. bisinuatus, Macl.
A. brevicollis, Macl.
A. cylindricollis, Macl.
A. cylindricus, Masters.
    subcylindricus, Westw. (n.pr.).
A. darlingensis, Macl.
A. denudatus, Westw.
    angusticornis, Macl.
A. depressus, Macl.

A. elongatulus, Macl.
A. foveicollis, Macl.
A. foveipennis, Blackb.
A. hirtus, Macl.
A. hopei, Westw.
A. howitti, Macl.
A. howittensis, Masters.
  howitti, Westw. (n.pr.).
A. humeralis, Macl.
A. kingi, Macl.
A. latipennis, Macl.
A. macleayi, Don.
A. mastersi, Macl.
A. melbournii, Westw.
A. montanus, Macl.
A. occidentalis, Blackb.
A. odewahnii, Macl.
A. ovicollis, Macl.
A. parallelocerus, Westw.
A. picipes, Macl.
A. politus, Macl.
A. punctatissimus, Westw.
A. puncticollis, Macl.
A. quadricollis, Westw.
A. riverinae, Macl.
A. rockhamptonensis, Macl.
A. scutellaris, Macl.
A. subampliatus, Macl.
A. subsulcatus, Westw.
A. turneri, Macl.
A. waterhousei, Macl.
A. wilsoni, Westw.
A. wyanamattae, Macl.
Phymatopterus macleayi, Westw.
  distinctus, Thoms.
P. piceus, Westw.
Paussus australis, Blackb.
Megalopaussus amplipennis, Lea.

Scydmaenidae.

Scydmaenus clientulus, n.sp.

Dark reddish—or brownish—castaneous, under surface darker, appendages somewhat flavous. Clothed with rather sparse, straggling hair, or fine setae, but becoming fairly dense on sides of prothorax.

Head smooth, with small prominent eyes. Antennae just passing base of prothorax; with a distinct four-jointed club, which is about equal in length to the six preceding joints combined. *Prothorax* slightly longer than wide, apex and apical sides rounded, base scarcely narrower than greatest width; with four deep basal punctures, and a slightly oblique longitudinal impression on each side towards base. *Elytra* oblong-ovate, somewhat flattened, sides gently rounded, with a shallow depression on each side of base; with sparse, indistinct punctures. Front *tibiae* rather strongly inflated to apex. Length 1 mm.

Hab.—Tasmania: Burnie, in a nest of a small variety of *Ectatomma metallicum* amongst stones close to sea beach (A. M. Lea).

The front tibiae are dilated somewhat as in *gulosus* (this, however, appears to be a masculine character only), but the elytra and antennae are darker, and the antennae are somewhat shorter. The whole upper surface is of an almost uniform shade of colour.

Scydmaenus colobopsis, n.sp.

Reddish-castaneous, appendages paler. Clothed with pale and rather sparse, straggling hair or fine setae, becoming dense on sides of prothorax, and almost or quite absent from its disc.

Head and antennae as described in preceding species. *Prothorax* scarcely longer than wide, outlines much as in preceding species, base with four deep punctures, feebly connected by a shallow transverse impression, which on each side becomes a short deep groove. *Elytra* depressed, oblong ovate, sides gently and regularly rounded; basal impressions feeble; with sparse indistinct punctures. Front *tibiae* in one sex rather strongly inflated to apex. Length 1 mm.

Hab.—Tasmania: Swansea. One specimen from a nest of *Colobopsis gasseri* (A. M. Lea).

The males have the front tibiae dilated as in *gulosus*, but the head and prothorax are much darker in that species. The club of the antennae is rather stouter than in the preceding species, but is otherwise the same, the sides of the prothorax are rather more densely clothed. The elytra are somewhat wider and the whole insect slightly larger.

From some directions the elytra appear to be of the same shade of colour as the prothorax, but from others they appear to be paler.

Scydmaenus daveyi, n.sp.

Of a bright castaneous, appendages paler. Upper surface with sparse pubescence, but becoming longer and denser on sides of prothorax.

Head smooth, eyes distinct but not prominent; antennae as in *clientulus*, except that the eighth joint is somewhat smaller, although distinctly part of the club. *Prothorax* slightly longer than wide, sides widest and gently rounded near apex, base with four large punctures or small foveae, the two on each side shallowly connected with each other, but the two median ones separated by a feeble ridge or carina. *Elytra* oblong-ovate, rather strongly inflated to near middle; basal impressions rather shallow; with sparse indistinct punctures. Front *tibiae* moderately inflated towards apex. Length 4-5th mm.

Hab.—Victoria: Forrest, Geelong, in nests of a small black ant *Colobopsis*? (H. W. Davey).

Close to *castaneoglaber*, but antennae thinner, elytra not quite so highly polished and not quite glabrous. From *colobopsis* it differs in being smaller, elytra with sparser and much shorter clothing, sides of prothorax much less densely clothed, and antennae thinner.

Scydmaenus glabripennis, n.sp.

Head and prothorax blackish brown, under surface somewhat paler; elytra brightly castaneous, suture somewhat darker; appendages somewhat, the tarsi quite, flavous. Head at base, and prothorax at apex and sides, with fairly dense reddish hair or fine setae; rest of upper surface almost or quite glabrous.

Head smooth; eyes small and very prominent. Antennae very distinctly passing base of prothorax, with a very distinct four-jointed club. *Prothorax* slightly longer than wide, basal two-thirds subparallel, thence narrowed to apex, with a deep puncture on each side of middle of base, and a smaller one on each side. *Elytra* somewhat depressed, briefly oblong-ovate, sides strongly rounded from base to apex; basal impressions distinct; impunctate. *Legs* long and thin; femora clavate; hind tibiae long and bisinuate internally, the others slightly thickened towards apex. Length $1\frac{1}{2}$ mm.

Hab.—Tasmania: Devonport, in a nest of *Polyrachis hexacantha* (A. M. Lea).

The dark head and prothorax, with dense clothing at sides of latter, and the highly polished and glabrous elytra, will readily distinguish from all previously named Australian species. There are, however, several as yet unnamed species that are fairly close to it in appearance.

I have regarded the club as four-jointed, but it might almost fairly be regarded as five-jointed, as the seventh joint, although decidedly narrower than the eighth, is dilated to its apex, and very distinctly longer than the sixth. The hind tibiae are probably simple in the female. From some directions the median prothoracic punctures appear to be completely isolated, but from others they are seen to be connected by a shallow impression.

Scydmaenus ectatommae, n.sp.

Brownish castaneous, metasternum and abdomen almost black, appendages of a dingy pale brown. Sparsely pubescent.

Head smooth; eyes distinct but not very prominent. Antennae comparatively stout, scarcely passing base of prothorax; with a very distinct, four-jointed club, that is equal in length to the six preceding joints combined. *Prothorax* slightly longer than wide, apex and apical sides rounded, slightly wider at apical third than elsewhere; base with four small, deep, completely isolated punctures. *Elytra* oblong-ovate, sides rather strongly inflated about middle; basal impressions very feeble; with very sparse, indistinct punctures. Length $1\frac{1}{4}$ mm.

Hab.—Tasmania: Hobart, Bagdad, Huon River, Launceston, in nests of *Ectatomma metallicum* (A. M. Lea).

A rather dingy species. The absence of dense clothing from the sides of prothorax will readily distinguish from any of the preceding species. The median prothoracic punctures are very distinct from certain directions, but indistinct from others.

Scydmaenus duplicatus, n.sp.

Reddish castaneous, appendages paler. Upper surface sparsely clothed with pale, straggling hair or fine setae, becoming denser (but not very dense) on sides of prothorax.

Head and antennae as described in *clientulus.* *Prothorax* distinctly longer than wide, widest almost in middle, which is gently rounded; base with four deep, isolated punctures, of which the two median ones are slightly larger than the others, each side with a partially concealed oblique impression. *Elytra* oblong ovate, sides rather strongly rounded; basal depressions rather feeble; with sparse, indistinct punctures. Length 1 mm.

Hab.—W. Australia: Swan River, in an ants' nest (A. M. Lea).

In general appearance close to *daveyi*, but more elongate and prothoracic punctures distinctly isolated, although close together. From some directions the elytra appear to be slightly paler than the prothorax.

Scydmaenus castaneoglaber, n.sp.

Of a bright pale castaneous and highly polished, appendages paler. Upper surface glabrous except for a very few hairs or fine setae at sides of prothorax.

Head very smooth and rather wide; eyes small and fairly prominent. Antennae distinctly, but not by much, passing base of prothorax, with a distinct four-jointed club, that is as long as the six preceding joints combined. *Prothorax* about as long as wide, basal two-thirds parallel-sided, apical third strongly narrowed; each hind angle with a single deep puncture. *Elytra* briefly oblong ovate, depressed, sides strongly inflated in middle; basal depression deep but not large; impunctate. *Legs* long; femora clavate; hind tibiae longer than usual. Length 4-5th mm.

Hab.—Tasmania: Parattah, in a nest of *Colobopsis gasseri* (A. M. Lea).

A short, pale, highly polished species.

Scydmaenus microps, n.sp. (Fig. 10.)

Pale reddish castaneous, appendages slightly paler, somewhat infuscated at junction of prothorax and elytra. Elytra with sparse and very short pubescence, rest of upper surface with somewhat longer clothing.

Head smooth, regularly dilated from a strong basal constriction to between antennae; eyes minute and invisible from above. Antennae thin, none of the joints transverse, distinctly passing base of prothorax; with a distinct four-jointed club, the joints of which are much thinner than usual. *Prothorax* longer than wide, sides distinctly rounded, and widest slightly nearer apex than base; base with four distinct punctures. *Elytra* oblong-ovate, at base scarcely wider than base of prothorax, but at widest (just beyond the middle) about twice as wide; basal impressions feeble; punctures rather sparse and indistinct. *Legs* long; femora clavate. Length $1\frac{1}{2}$ mm.

Hab.—W. Australia: Swan River, in a nest of *Ponera lutea* (A. M. Lea).

Readily distinguished from all previously described Australian species by the shape of its head, small eyes and thin antennae. The second joint of the antennae is as long as the third and fourth combined, but this proportion is much as in all the preceding species. In size and appearance, except for shape of head, much like *optatus*, but the club also is very different. Both front tibiae and tarsi are missing in the type.

Scydmaenus simplicicornis, n.sp.

Deep shining black, antennae, abdomen and base of femora piceous, or diluted in parts with red, palpi and tarsi flavous. With rather sparse pale pubescence.

Head transverse; eyes small and fairly prominent; clypeal sutures distinct. Antennae long and thin, fully four of their joints passing base of prothorax, not clubbed, first joint partly concealed from above, almost as long as second and third com-

bined, second very little longer than third, third to tenth subequal or very feebly increasing in length, eleventh as long as ninth and tenth combined. *Prothorax* slightly longer than wide, rounded at apical third, with sides strongly diminishing in width to apex, and gently to base; base with a feeble transverse impression; with minute, scattered punctures. *Elytra* oblong-ovate, at base scarcely wider than base of prothorax, rapidly increasing in width to basal third, thence gently rounded to apex; base gently conjointly arcuate and without depressions; with sparse but, for the genus, fairly distinct punctures. *Legs* long; femora clavate; tibiae somewhat thickened about basal third, then slightly narrowed. Length 2 mm.

Hab.—Victoria: Geelong, in a nest of *Iridomyrmex nitidus* (H. W. Davey).

I have not been able to examine the labial palpi of the type, and the species may eventually be regarded as belonging to a new genus, but at present I think it is best referred to *Scydmaenus*. At first glance it rather strongly resembles an *Anthicus*.

From some directions the extreme elytral margins appear reddish. The abdomen is strongly notched at apex, the notch fringed with fine pubescence; but this is probably a male characteristic. All the tibiae are thickened about the basal third, but the middle pair less noticeably than the others.

Scydmaenus optatus, Sharp.

In the original description of this species no mention is made of an impression between the antennae; but on seven specimens from W. Australia before me such an impression is quite distinct. The species is readily identifiable by its two jointed club, with the ninth joint more than twice as long as wide, and about as long as the two preceding combined.

Sharp simply records it from West Australia. I have taken it at Swan River, Newcastle, and Donnybrook, and in the nests of *Camponotus dorycus* and *Ponera lutea*.

Two specimens from N.S. Wales (National Park—H. W. Cox—from a nest of *Ponera lutea*), and one from Victoria (Sea Lake

—J. C. Goudie—from the nest of an unspecified ant), differ from the typical form in having no impression between the antennae, but as I can discover no other distinguishing feature, I have not considered it advisable to treat them as distinct.

Scydmaenilla pusilla, King.

Six specimens, apparently belonging to this species, were sent by Mr. H. W. Cox from Sydney and the National Park (N.S. Wales) as having been taken from nests of *Ponera lutea*.

Scydmaenilla constricta, n.sp.

Reddish castaneous; appendages and abdomen somewhat paler. Upper surface uniformly, but not densely, clothed with straggling yellowish hair or fine setae; shorter and denser on under surface.

Head very shallowly impressed between eyes, these small and prominent. Antennae just passing base of prothorax, with a distinct three-jointed club, which is about the length of the six preceding joints combined. *Prothorax* distinctly longer than wide, apex and apical sides rounded, basal third somewhat narrowed; with a strong, continuous transverse impression at about basal third, the impression simple across middle but with punctures at sides. *Elytra* oblong-ovate, greatest width about twice that of prothorax; with a distinct impression on each side of base; with sparse indistinct punctures. *Legs* long; hind coxae touching; femora clavate. Length 1 1-5th mm.

Hab.—Tasmania: Hobart, in nests of *Amblyopone australis* (A. M. Lea).

Decidedly larger and somewhat wider than *pusilla*, and with longer clothing.

Heterognathus carinatus, King.

Occurs in the nests of several species of ants, including *Iridomyrmex nitidus*, an allied species in W. Australia; and in nests of a species of termites.

Hab.—Victoria (Sea Lake, Birchip, Ocean Grove), N.S. Wales (Liverpool), W. Australia (Swan River).

Heterognathus princeps, King.

Recorded by King as associated with the preceding species in an ants' nest. I have taken the species at Glen Innes (N.S. Wales), but have no record as to how obtained.

Phagonophana kingi, King.

Mr. Cox informs me that he has taken this species in nests of *Iridomyrmex rufoniger*.

Phagonophana latipennis, n.sp.

Reddish-castaneous, elytra (suture and base excepted), and legs somewhat brighter. Upper surface with fairly dense, straggling, reddish hair, denser at base of head than elsewhere; under surface and legs with shorter, denser and paler clothing.

Head convex; eyes prominent and rather coarsely faceted. Antennae passing base of prothorax, feebly increasing in width to apex, and not clubbed, eleventh joint about as long as ninth and tenth combined. *Prothorax* distinctly longer than wide, apex rounded, sides gently incurved between middle and base; with a large, round, deep puncture, or small fovea, on each side of base, but normally more or less concealed, each side towards base with a similar puncture or fovea. *Elytra* distinctly wider at base than prothorax, increasing in width to about middle and then rapidly diminishing; with a wide, shallow impression on each side of base; and with a few indistinct punctures. *Legs* long; femora strongly clavate. Length 3 mm.

Hab.—W. Australia: Bridgetown, numerous specimens obtained under a log on sandy ground in the company of ants (A. M. Lea).

In general appearance close to *kingi*, but elytra considerably wider (fully one-fourth more) and less convex, much wider at base, with more pronounced humeral ridges; their clothing also is sparser and longer. The femora also, although almost as stout at their widest, are not so suddenly inflated.

The male differs from the female in being narrower, with slightly longer legs, and apex of abdomen not simple.

Phagonophana macrosticta, n.sp. (Fig. 11.)

Dark reddish castaneous, palpi slightly paler, knees somewhat infuscated; elytra black, with three large reddish spots, one on each side of middle and the other apical. With rather dense reddish pubescence, denser and shorter on head and prothorax than on elytra, and very short on under surface.

Head (excluding mandibles) almost as long as wide; with small more or less concealed punctures. Eyes prominent and coarsely faceted. Antennae passing middle coxae, joints very feebly but regularly increasing in width, the apical ones not clubbed, eleventh subcylindrical but its apex conical, slightly longer than ninth and tenth combined. *Prothorax* slightly longer than wide, widest near apex, sides thence regularly decreasing in width to base; each side of base with two small but deep foveae, the sides with some smaller more or less concealed ones. *Elytra* at base scarcely wider than base of prothorax, rather strongly dilated to about the middle, and then strongly diminishing in width to apex; with a large fovea on each side of base; punctures indistinct. *Femora* stout, lower surface finely grooved. Length 2 2-3rd mm.

Hab.—Tasmania: Marrawah (A. M. Lea).

Readily distinguished from *kingi*, and the preceding species, by the dark elytra with conspicuous markings. The apical spot commences on the suture about summit of the posterior declivity, the median ones do not touch the sides or suture, and each extends from about the basal fourth to slightly beyond the middle. The femora at the apex are almost as stout as in those species, but the inflation is much less abrupt, and they are finely but distinctly grooved almost throughout.

One specimen was taken from an ants' nest[1] under a stone, a second under a near by stone but not associated with ants.

SILPHIDAE.

Anisotoma myrmecophila, n.sp.

Castaneous, appendages somewhat paler; club infuscate.

Head with small dense punctures. *Prothorax* with numerous but very indistinct punctures. *Elytra* with regular rows

1 A small reddish-brown species, probably an *Iridomyrmex*.

of rather small punctures, becoming smaller towards base and absent from shoulders; interstices with very minute but rather clearly defined punctures, as distinct on shoulders as elsewhere. *Metasternum*, except in middle, with dense and rather coarse punctures. *Legs* short and wide; hind femora with a thin flange-like extension at inner apex; front tibiae somewhat inflated, and with a few stiff bristles, four hind ones strongly dilated to apex and with short stiff bristles. Length 2 mm.

Hab.—Tasmania: New Norfolk—a single specimen from a nest of *Colobopsis gasseri* (A. M. Lea).

Much like *tasmaniae* in general appearance, but distinctly smaller, and hind femora edentate, although at apex they have a thin flange-like extension which partially covers the tibiae when at rest.

Clambus myrmecophilus, n.sp.

Black, highly polished; appendages, hind coxae excepted, reddish flavous. Glabrous.

Upper surface apparently impunctate; subsutural striae absent. Hind *coxae* with very minute punctures, and, as also the metasternum and abdomen, highly polished. Length 1 mm.

Hab.—Victoria: Portland, in a nest of a small variety of *Ectatomma metallicum* (H. W. Davey).

In general appearance something like *tierensis*, but subsutural stria absent and under surface very different. The highly polished hind coxae and metasternum will readily distinguish from *simsoni*, and the colour from *tropicus*.

Although from some directions the upper surface appears to be entirely black, from others the tips of the elytra and sides of the prothorax appear to be diluted with red. The club is concealed on the type. The hind coxae are fully twice as large as the metasternum.

Myrmicholeva, n.g.

Head small, with a wide concealed neck. Eyes small, prominent, latero-basal, moderately faceted. Clypeus rather large and narrowed in front. Antennae slightly thickened towards apex, but not clavate. Mentum wide. Labial palpi minute.

Maxillary palpi four-jointed; first joint almost entirely concealed, second long and rather thin, third short and subtriangular, fourth elliptic ovate, not much shorter than second. *Prothorax* transverse, base strongly bisinuate, each side with a conspicuous stria commencing near the apex on the extreme margin, and curved round so as to touch the base half-way between side and scutellar lobe. *Scutellum* small. *Elytra* elliptic or elliptic-ovate, epipleurae fairly wide at base, and very narrow at apex. *Prosternum* with distinct sutures, not carinated along middle. Mesosternum narrowly produced between coxae. Metasternum moderately long; episterna narrow in front, gradually widened posteriorly. *Abdomen* with six segments, the apical one very small or sometimes concealed. Front coxae large, conical, prominent, cavities open behind; middle pair almost touching; hind pair lightly separated, sides almost touching elytra; trochanters rather small; femora rather long and thin, edentate; tibiae thin, apical spurs minute; tarsi five-jointed, rather thin but basal joints of the two front pairs inflated in male; claws thin and simple. *Body* winged.

Although there are four species before me I have not been able to examine the mouth parts at all well. But, both from above and below, they appear to be produced into a more or less triangular tongue, with the labial palpi not very far from its tip. The mouth parts are certainly not like those of any other Australian *Silphidae* known to me, but as in its other characters and general appearance the genus appears to belong to the *Silphidae*, and, in addition, Mr. Blackburn has suggested the probability of its belonging to that family, I am content for the present to place it there. Amongst the Australian genera it may be provisionally placed near *Choleva*.

At least two of the species here described were taken in ants' nests; a third was taken in moss, but was probably there associated with ants, as many were seen when picking over the moss for insects. The fourth was probably also from an ants' nest, although I have now no record as to how it was taken. I know, however, that I paid very considerable attention to ants' nests whilst at Karridale.

Myrmicholeva lata, n.sp. (Fig. 43.)

Blackish brown, margins and suture slightly diluted with red; appendages pale castaneous, but tibiae and antennae (except basal and apical joints) somewhat darker. With moderately dense and rather long straggling hairs; under surface and appendages moderately pubescent.

Head strongly transverse between clypeal suture and neck, but including mandibles longer than wide; densely and rather coarsely punctate; labrum more than twice as wide as long; punctures sparser and smaller than on rest of head. Antennae almost extending to hind coxae, first joint lightly curved; slightly longer than third, and distinctly longer than second, second to fifth subcylindrical, fourth slightly longer than fifth and slightly shorter than third, sixth slightly shorter than fifth, seventh slightly wider but no longer than sixth, eighth the width of seventh but slightly shorter, ninth and tenth slightly larger and feebly transverse, eleventh slightly wider than tenth, but very little longer except on one side where it is produced into a moderately acute point. *Prothorax* rather strongly convex, scarcely twice as wide as long, sides strongly rounded, apex decidedly narrower than base and gently incurved to middle, stria on each side strongly impressed and marking off a flattened outer portion; punctures fairly numerous but very small. *Elytra* cordate, scarcely once and one-half as long as wide; with fairly strong punctures in feeble striae; interstices with very feeble punctures, the suture moderately raised posteriorly. Length 3 mm.

Hab.—W. Australia: Bridgetown, from an ants' nest (A. M. Lea).

The four front tarsi of the type are somewhat inflated, but much less noticeably so than in the type of *ligulata*; but it is probably a male.

Myrmicholeva acutifrons, n.sp. (Fig. 44.)

Flavous or castaneous, some parts darker. With moderately long, pale pubescence, becoming short on under surface.

Head (behind clypeal suture) strongly transverse, but including mandibles slightly longer than wide, the apical portion

acute; with clearly defined but not very dense or coarse punctures, becoming small on labrum. Antennae just passing middle coxae, second joint slightly shorter than second, and slightly longer than third, third, fourth and fifth subequal, sixth slightly smaller, seventh larger and transverse, eighth smaller, ninth and tenth larger and slightly more transverse, eleventh briefly ovate, slightly shorter than ninth and tenth combined. *Prothorax* moderately convex, not twice as wide as long, apex not much narrower than base, and gently incurved to middle, sides moderately rounded, sublateral striae close to margin on apical three-fifths, and thence deep and oblique to base; punctures very indistinct. *Elytra* more than twice as long as wide, shoulders moderately, sides very feebly rounded; with strong punctures in rather feeble striae; interstices with feeble punctures, suture scarcely raised posteriorly. Length 2—2 1-6th mm.

Hab.—Victoria: Forrest (H. W. Davey), Somerville (A. M. Lea); Tasmania: Burnie, Frankford (Lea).

The specimens vary considerably in colour; those from Forrest are flavous, with the under surface and apical half of antennae somewhat darker, a Burnie specimen has the same shades of colour, whilst another has the general tone castaneous, with the prothorax (except at base) and head darker than elsewhere; the Somerville specimen has these parts almost black. The head appears to be produced into a subtriangular joint. The four front tarsi of the male are somewhat dilated towards the base, but otherwise the sexual differences are not pronounced.

Mr. Davey sent the specimens in spirits together with several larvae, which he believed to belong to the species. Unfortunately in the same tube were some other ants' nest insects, and thinking the larvae in question were simply sent as being from a nest they were not kept; as the tube was received some days before the explanatory letter. The beetles themselves were taken from right in the middle of a nest of small black ants in a log.

In the preceding species and in *ligulata*, the sublateral striae of the prothorax almost regularly increase in distance from the margins, although the distance is considerably increased posteriorly; but in the present species they are almost marginal

to the basal two-fifths; when they suddenly become oblique to the base; in the following species they are intermediate between this and the preceding species.

Myrmicholeva punctata, n.sp. (Fig. 45.)

♀. Of a pale but rather dingy castaneous, prothorax (except sides and base), head, apical half of antennae and under surface somewhat darker. Moderately densely clothed with long pubescence or short hair, becoming much shorter on under-surface.

Head behind clypeal suture and across the eyes about twice as wide as long, but including mandibles about as long as wide; with clearly defined and moderately dense punctures, becoming sparser and smaller on labrum, which is about thrice as wide as long. Antennae much as in preceding species, except that the second joint is still shorter than the first, although slightly longer than the second. *Prothorax* strongly convex, about twice as wide as the length down middle, sublateral striae deeply impressed, with the margins somewhat flattened; disc with dense and clearly defined punctures, becoming smaller towards sides. *Elytra* much as in preceding species, except that they are slightly shorter, with slightly stronger punctures. Length 2¼ mm.

Hab.—W. Australia: Karridale (A. M. Lea).

In general appearance very close to the preceding species, but readily distinguished therefrom by the conspicuous prothoracic punctures. As all the tarsi are thin at the base the type is certainly a female.

Myrmicholeva ligulata, n.sp. (Fig. 12.)

♂. Dark reddish castaneous, appendages paler; under-surface (tip of abdomen diluted with red) almost black. Densely clothed with rather long pale pubescence, becoming somewhat shorter and sparser on under surface.

Head between clypeal suture (which is rather indistinct) and neck about twice as wide as long; with clearly defined but rather small and not very dense punctures; labrum longer and more convex than in all the preceding species and almost

impunctate; apparently with a rather long tongue in front, so that from its tip to the base of the head that part is almost twice as long as wide. Antennae extending to hind coxae, first to sixth joints subcylindrical, seventh to tenth slightly dilating to their apices; first almost twice as long as second, third about once and one-half as long as second, and distinctly longer than fourth, fifth and sixth slightly diminishing in length, seventh a trifle larger than sixth, which is just perceptibly larger than eighth, ninth larger and feebly transverse, tenth slightly shorter than ninth, but the same width, eleventh not much longer than ninth, except on one side where it is moderately produced. *Prothorax* scarcely once and one-fourth as wide as long, sides moderately rounded, apex distinctly narrower than base, and very feebly incurved to middle; sublateral striae deeply impressed, the margins less convex than the disc but scarcely flattened; with fairly numerous but very minute punctures. *Elytra* elongate subcordate, almost twice as long as wide; with moderate punctures in moderate striae; interstices with numerous small but fairly distinct punctures, suture scarcely separately raised posteriorly. Length 3 2-3rd mm.

Hab.—Tasmania: Waratah, in moss (A. M. Lea).

From some directions the elytra appear to have the suture paler than the sides, but from others they appear to be of uniform colour. The basal joints of the four front tarsi on the type are very wide, on the front pair the first joint is distinctly wider than the tibia, and subtriangularly dilated from its base to its apex, the second and third are small and strongly transverse; on the middle pair the three basal joints are somewhat smaller, with the first joint less triangular and no wider than the tibia.

The species may be tabulated as follows:—

Elytra much less than twice as long as wide - - - *lata*
Elytra about, or more than, twice as long as wide.
 Second joint of antennae shorter than third - - *ligulata*
 Second joint longer than third.
  Prothorax with feeble punctures - - *acutifrons*
  Prothorax with clearly defined punctures - *punctata*

TRICHOPTERYGIDAE.

Rodwayia.

A curious genus of blind species, quite commonly found in the nests of many species of ants. Its nearest ally (*Limulodes*) also occurs in the nests of ants in N. America.

Rodwayia minuta, Lea.

Quite common in nests of *Colobopsis gasseri*, and occasionally with *Ectatomma metallicum*.

Rodwayia occidentalis, Lea.

Occurs in nests of a *Camponotus*[1] under stones.

Rodwayia orientalis, Lea.

Occurs in nests of *Colobopsis gasseri*, *Ectatomma metallicum*, *Pheidole tasmaniensis* and *Iridomyrmex rufoniger*.

Rodwayia ovata, Lea.

Abundant in nests of the common *Polyrachis hexacantha*, and also to be taken with *Camponotus novae-hollandiae*.

HISTERIDAE.

Paromalus miliaris, Mars.

Two specimens from Forrest and Portland sent at different times by Mr. Davey as occurring in the nests of "the small black ants that mostly nest in trees and run about with their abdomens cocked in the air." One of the specimens "found in centre of nest." It appears, however, only to be an occasional visitor.

Chlamydopsis and Orectoscelis.

Of these remarkable and allied genera nine species have been described, and all with the exception of *formicicola*, apparently from single specimens. I have now to add six more, also all

1 In general appearance fairly close to *C. novae-hollandiae*.

from single specimens. The reason for this paucity of material is probably the fact that, whilst many ants' nests have been superficially examined, they have seldom been specially searched for species of these genera, and their deceptive resemblance to ants or insect remains is very strong; when mounted this resemblance would hardly be thought possible. They probably also, except when coming out to mate, live deep in the nests. Probably when nests have been systematically dug out in Australia and sent through sieves, etc., they will be found more plentifully. Although several of the specimens described were not taken in ants' nests, there is no doubt but that all the species are truly myrmecophilous.

Orectoscelis humeralis, Lewis.

Taken by Dodd from an ants' nest at Townsville, and so recorded by Lewis.

Chlamydopsis comata, Blackb.

Described from "A single specimen found in a pool of water."

Chlamydopsis duboulayi, Westw.

Taken originally by Duboulay, who frequently examined the nests of ants; but ants are not mentioned at the foot of the description.

Chlamydopsis formicicola, King (*Byzenia*). (Fig. 15.)

This species was recorded by Lewis as a synonym of *striatella*, but this is not correct. It differs in many respects from *striatella* (of which I have a Swan River—the type locality—example) but in particular by the shoulders and striation. The following remarks by King, on the elytra, apply only to this species of all the genus known to me:—"They are marked by four strong ridges, all rising towards one point, and nearly meeting behind the shoulder, the apparent perforation between the points being fringed with a few stiff yellowish setae."

I have, from the late Rev. R. L. King's collection, two specimens which were obtained as co-types of *Byzenia formicicola*, and from Liverpool (the type locality). Mr. Froggatt also sent me a specimen. King described the colour as "Piceus," and

said, "The species is readily known by its black colour," but my specimens are of a chestnut brown colour. To be quite certain, therefore, I sent my third specimen to Mr. Rainbow for comparison with the types, and in reply he wrote, "I have carefully examined your specimen with King's types, and there can be no doubt that they are one and the same species, the only difference being that yours is a shade darker; neither of them are black." There can be no doubt therefore but that King wrongly described the colour as black, and in fact he appeared to regard all fairly dark shades of colour as black. On Mr. Rainbow returning the specimen it was forwarded to Mr. Lewis, who wrote of it: "The specimen of *Chl. formicicola* is quite distinct from *striatella.*"

Chlamydopsis inaequalis, Blackb.

Described from a single specimen from the top of a rotten fence post "in which *Hymenoptera* were making their nests."

Chlamydopsis inquilina, Lewis.

"Reported as occurring in ants' nests" (Lewis).

Chlamydopsis pygidialis, Blackb.

"Obtained by beating dead branches and probably connected with some species of *Hymenoptera* inhabiting the dead wood" (Blackburn).

Chlamydopsis sternalis, Blackb.

The type was taken in the same way as the type of *inaequalis*.

On comparing *Chlamydopsis* and *Orectoscelis* Lewis states, "In the genus *Orectoscelis* there is no prosternal keel, and *C. duboulaii* certainly (from Westwood's figure) and *C. sternalis*, Blk., probably belong to it." But so far as *sternalis* is concerned he must be in error, as Blackburn states of that species, "prosterno medio longitudinaliter late fortiter carinato, carina media longitudinaliter profunde sulcata."

Chlamydopsis striatella, Westw.

"Reported as occurring in ants' nests" (Lewis). A specimen before me was beaten from dwarf *Eucalypti* at Fremantle.

Chlamydopsis reticulata, n.sp. (Fig. 16.)

Brownish castaneous, appendages somewhat paler. Glabrous, except for humeral membranes, and some sparse pubescence on appendages.

Head with shallow reticulate punctures. Antennae fitted into grooves at apex of prothorax, basal joint very large, with punctures as on head, curved, with a strong inner groove; club about as long as basal joint, lightly curved and subcyclindrical. *Prothorax* about twice as wide as long, disc gently convex; front margins narrowly but distinctly raised, sides gently incurved to middle; with regular, shallow, reticulate punctures. *Elytra* about as wide as long; with a wide, deep, highly polished, subbasal impression, which, close to the base has a flattened space on each side of scutellar region terminating abruptly; shoulders in the form of raised, arched, striated epaulettes beyond each of which projects a fine and rather short membrane covered with golden pubescence, each epaulette separated from base by a narrow wedge-shaped space, and bounded posteriorly by a distinct notch; middle beyond subbasal depression finely striated, the striae towards apex merging into punctures as on prothorax, similar punctures elsewhere; each side with a large shallow depression about middle and a smaller one about apex; outer margins with strong striae converging to subbasal notches. *Pygidium* and propygidium with punctures as on prothorax, but becoming feeble at apex. *Prosternum* not ridged along middle, but with a narrow oblique ridge on each side marking the inner side of the femoral receptacle; punctures in middle as on pronotum but becoming obliterated at sides. Mesosternum with a wide, punctate, intercoxal process. Metasternum impunctate. *Abdomen* with punctures towards sides and a row of small ones at base of intercoxal process. *Legs* rather long; tibiae near base suddenly and strongly inflated and then gently narrowed to apex, the inflated parts thin and each with a shallow groove for the reception of tarsi. Length $2\frac{1}{3}$ mm.

Hab.—Australia (a single specimen, without locality label, from the late Rev. R. L. King's collection).

In many respects close to *striatella*, but the depressed basal part of elytra with a greater portion highly polished, the epaul-

ettes larger and from some directions apparently free, the hollows they cover larger, with the tuft of golden hair much longer (although not as long as described in *comata*). Each of these tufts, under a Coddington lens, appears to be a fine membrane covered with golden pubescence. The metasternum also has not a row of distinct punctures close to its side pieces, but is impunctate to its sutures. In many respects it is close to the description of *inaequalis*, but the upturned margin of prothorax is not in six lobes but four, the two median small and rounded, the others much larger, and sweeping round with an even curve to the sides, but the inner corners appear almost like the two inner lobes; *inaequalis* also is not described as having subhumeral fascicles or membranes, and is almost twice the length.

The subbasal depression of the elytra is covered towards the sides by the epaulettes, but at each side appears as the notch. The inflated portion of the four hind tibiae commences at about the basal two-fifths; on the front tibiae it is not so pronounced and commences rather nearer the base.

On this and several other species parts of the derm are covered with a dense network of fine ridges, dividing the parts affected into numerous honeycomb-like areolets; in the strict sense of the word they are probably not punctures.

Chlamydopsis excavata, n.sp. (Fig. 17.)

Dark piceous-brown, pronotum almost black, legs castaneous. Prothorax, head, py- and propygidium with short and rather sparse pubescence, apex of elytra and legs with much sparser pubescence, membranes pubescent, elsewhere glabrous.

Head with shallow reticulate punctures. Antennae with basal joint large with punctures as on head. *Prothorax* about twice as wide as long; disc gently convex; margins feebly raised in middle of apex into two rounded lobes, thence to sides more distinctly raised and sweeping round antennary receptacles with a rather strong curve; sides almost parallel; with punctures as on head. *Elytra* about as long as wide; highly polished; with a deep, wide excavation commencing at base, widest at about basal third, then narrowed with strong and regularly

diminishing walls till it opens out at about two-fifths from apex; about base on each side of scutellar region with a feebly raised space within the excavation; shoulders in the form of strongly raised eqaulettes, projecting beyond each of which is a membrane; surface impunctate; outer margins with strong striae converging to subbasal notches. *Pygidium* and propygidium obsoletely reticulated. *Under surface* and *legs* as described in preceding species. Length $2\frac{1}{3}$ mm.

Hab.—Tasmania: near Hobart (A. M. Lea).

In its shining elytra, which from some directions appear to be quite glabrous, agrees with description of *comata*, but with little else in common. The antennae on the type are completely immersed within the prothoracic grooves, so that only the outer side of the basal joint of each is visible, with the tip of the club. The epaulettes are of the same shape and size as the preceding species, and are similarly bounded, but they are non-striated; projecting beyond them also are similar golden clothed membranes. Many of its features exactly resemble those of the preceding species. The type was obtained near Brown's river under a stone which covered the nests of three species of ants—

1. Myrmecia pyriformis.
2. Ectatomma metallicum.
3. Pheidole conflicta.

Chlamydopsis longipes, n.sp. (Fig. 18.)

Black or almost so; head, pronotum, apex of prosternum, epaulettes and appendages reddish castaneous. With sparse short setae scattered about on body and appendages.

Head with shallow reticulate punctures. Antennae with basal joint large, curved, of irregular shape, with a deep inner groove and with punctures as on head; club large, gently curved and subcylindrical. *Prothorax* about once and one-half as wide as long, disc moderately convex; front margins narrowly raised and divided into lobes, sides gently incurved to middle, but with minute subgranular projections; with uniform punctures as on head. *Elytra* slightly longer than wide; with a large, wide, basal impression, which on each side of scutellar region has a

feebly elevated, flattened, feebly reticulated space; shoulders strongly elevated, and in the form of reticulated irregular epaulettes; behind these the elytra are strongly elevated, with each elevation strongly sloping inwards and rearwards, and vertical outwards; surface with punctures as on prothorax, except that about the inner walls of the post humeral elevations they become striated; with small scattered granules; outer margins with strong striae converging to a depression, which is bounded by the outer wall of the outer humeral emargination. *Pygidium*, propygidium and under surface with punctures as on prothorax, but coarser on prosternum than elsewhere. *Prosternum* without ridges and femoral grooves. Metasternum fully as long as prosternum, with a narrow, continuous median line. *Abdomen* about two-thirds the length of metasternum. *Legs* very long; femora thickened towards apex and not grooved, four hind pair moderately curved; tibiae the length of femora, somewhat curved, without flange-like extensions, the two front pairs at about middle somewhat thickened (with the thickened portion commencing angularly), and thence to apex each with a groove for the reception of tarsi; the hind pair strongly thickened at apical two-fifths, with the thickened portion not commencing angularly, and densely granulate-punctate, terminated by a short distinct mucro, and with a narrow deep tarsal groove. Length 3 mm.

Hab.—Victoria: Bannockburn (H. W. Davey).

Apparently closer to *inaequalis* than to any other described species, but base of elytra and punctures not as in description of that species, and legs much longer (the four front legs of *inaequalis* are described as longer than the elytra, and the hind pair longer than the entire body; in the present species the four front legs are longer than the entire body, whilst the hind legs are twice the length of the body.

The raised front margin of the prothorax is divided into six small median lobes, but of these the two outer ones represent the inner ends of strong curved lines that sweep round the antennary receptacles; from some directions these curves appear quite regular, but from others each is seen to have a small median elevation. No part of the elytral excavation is highly polished and all parts are reticulated. The epaulettes each are

strongly emarginated; the inner emargination is semicircular, with its outer points overhanging the basal excavation in such a manner that a line between them would be oblique; looking down into this emargination there may be seen fine golden setae, and apparently remnants of a membrane, but there is no projecting membrane or fascicle as in some other species. The outer emargination is deep, but narrow to its apices, with the outer wall narrowly raised and oblique.

On presenting the specimen to me Mr. Davey wrote, "I have just returned home from Bannockburn, and when there took the most extraordinary ant-nest beetle that I have ever seen or heard of, the nest in which it occurred was under a large stone, the ants were small green metallic ones,[1] and after a little time this beetle came tumbling up out of one of the tunnels in a most comical way, and for a moment or two I took no particular notice of it, merely thinking it was the severed head and thorax of a slightly larger ant, the way it tumbled about in the sunlight (although it has very good eyes); the hind legs are greatly developed, and its antennae most peculiar."

Chlamydopsis glabra, n.sp. (Figs. 19, 46.)

Almost black, margins of elytra towards base, and all appendages more or less reddish castaneous. Glabrous.

Head impunctate. *Prothorax* almost twice as wide as long, disc gently convex and gently undulated to sides, which are not raised, apex gently incurved to middle, front angles strongly rounded off, sides thence gently increasing in width to base; impunctate. *Elytra* slightly longer than wide; with a strong, transverse, subbasal depression which is widest in middle, but of irregular shape, and terminated just before the margins; shoulders feebly depressed; sides gently sinuous; about middle with a wide, feeble, elongated depression, near apex with a somewhat curved and deeper one; with sparse, minute, irregularly distributed punctures; margins with a few minute scratches, but without striae. *Pygidium* and propygidium impunctate. *Under surface* with scarcely visible punctures. Prosternum without a median ridge, but with a fine oblique one on each

1 The ants belonged to *Ectatomma metallicum*.

side marking the side of the femoral groove. Metasternum almost as long as pro- and mesosternum combined, and distinctly longer than abdomen, with a narrow continuous median line. *Legs* rather long; hind coxae unusually large; femora grooved for reception of tibiae, and tibiae for reception of tarsi; tibiae with thin, wide, flange-like extensions. Length 4½, width 3 mm.

Hab.—N.S. Wales: Grenfell (E. W. Ferguson).

The total absence of striation and almost total absence of punctures (such as are present are very small and indistinct), with the smooth surface (although with depressed parts), absence of humeral tufts, and larger size, render this species very distinct. The absence of epaulettes with the very large hind coxae are probably indicative of generic rank, but the species of this genus (as also of *Articerus*) differ in so many important details that it seems advisable to allow very considerable latitude in features that ordinarily would be regarded as generic.

The pale elytral margins are very distinct, but rapidly merge into the general colour without a distinct dividing line; the apical half of their margins, as also the entire lateral margins of the prothorax, from some directions, are seen to be diluted with red, but from other directions appear scarcely, or not at all, paler than the general colour. Except for a few indistinct setae on the under surface of the tarsi, the insect is entirely glabrous. On the type the antennae are completely immersed with the receptacles for them, so that only the basal joint of each is visible. Each in area is about as large as the head, irregularly triangular in shape, and impunctate. Several of its legs are damaged, but the four hind tibiae each have a strong flange-like extension rather suddenly commencing about the basal third, and gradually diminishing, with a rounded outline, to apex.

Dr. Ferguson found the type on Weddin Mountains, September, 1907, under a log in company with remains of ants.

Chlamydopsis carbo, n.sp. (Figs. 20, 47, 48.)

Black, subopaque, legs reddish castaneous, elytral margins obscurely diluted with red. With a few short pale setae scat-

tered about on head, apex and sides of elytra, on pygidium, and legs.

Densely covered all over (less coarsely on elytral margins than elsewhere) with strong punctures of almost uniform size, the spaces between densely and minutely punctate. *Head* irregularly oblong, very gently concave. Antennae with basal joint large, curvilinearly triangular, and with much smaller punctures than on head. *Prothorax* slightly longer than wide, but slightly wider than long if a median projection be excluded; the projection occupies about three-fifths of the apex, is directed obliquely upwards and forwards so as to overhang the head, is deeply impressed along the middle from its apex to its base, with apex widely bilobed and the outer angles somewhat produced; sides bisinuate. *Elytra* quadrate; with an oblique impression on each side of base; behind each impression the shoulder, which is not elevated, projects forwards, and is tipped at the inner apex with a closely set oblique line of golden setae; apical angles strongly rounded. *Prosternum* longer than usual, each side of base with a strong femoral groove, marked internally by a fine oblique ridge, middle not ridged. Metasternum slightly shorter than abdomen, and distinctly shorter than prosternum. Basal segment of abdomen rather more than half its total length along middle, and more at sides. *Legs* wide, and, for the genus, rather short; femora grooved for reception of tibiae, and tibiae for tarsi; tibiae each with a wide flange-like extension, but on the front pair narrower than on the others. Length 2 2-3rd mm.

Hab.—Victoria: Sea Lake (J. C. Goudie).

The prothorax of *sternalis* seems to be crested somewhat as in this species, but the description of the prosternum, shoulders, etc., is very different. Mr. Blackburn referred *sternalis* and *inaequalis* to *Chlamydopsis*, but evidently with considerable hesitation. Mr. Lewis apparently regards the non-keeled prosternum as the main feature distinguishing *Orectoscelis* from *Chlamydopsis*, and this species should perhaps be referred to *Orectoscelis*, although probably a new genus will ultimately be proposed for it. This I do not venture to do at present, as the head of the type is retracted, with the antennae and eyes concealed, and to render them visible would probably mean its partial destruction.

In appearance it is like a little bit of charcoal, and I venture to suggest for it the "popular" name of "Goudie's charcoal beetle," the name by which it has been frequently mentioned in correspondence. It was taken by Mr. Goudie in a nest of very small ants under a board.

The punctures are very dense, but not net-like as in several species of the genus, nor do they anywhere become striated in appearance.

Chlamydopsis variolosa, n.sp. (Fig. 21.)

Dark brown, appendages more reddish; feebly shining.

Head immersed in prothorax; face vertical and with distinct and fairly numerous punctures. Antennae with basal joint large, irregularly triangular in shape, and about two-thirds the expanse of head. *Prothorax* about twice as wide as the length down middle, front margins narrowly raised and lobed, the lateral margins wider and less raised; with fairly large and rather dense punctures, the interspaces with smaller and dense ones. *Elytra* about as long as wide; with a wide irregular transverse depression near base, the depression scarcely punctate, but not highly polished; each side of suture at base with an obtuse densely punctate tubercle; between this and shoulder a large, subtriangular, raised, densely punctate space, its inner apical margin somewhat irregular; each shoulder divided from the medio-basal space by an oblique line, from the apex of which proceeds a small and thin pencil of hairs, its apex widely notched and sides irregularly obliquely striated, the striae all converging to the notch; behind medio-basal elevation on each side with an obtuse tubercular elevation; the surface elsewhere feebly undulating and with punctures much as on prothorax. *Under surface* and py- and propy-gidium with punctures as on pronotum, except that the larger ones are rather deeper and smaller. Prosternum feebly lobed in front, not depressed or carinated along middle. Metasternum slightly longer than pro- and meso-sternum combined, with a deeply impressed median line. *Abdomen* with basal segment about half the length of metasternum. *Legs* long, femora narrowly grooved; tibiae strongly inflated near base, and thence regularly narrowed to apex; tarsi long and thin. Length $2\frac{1}{3}$ mm.

Hab.—Queensland: Dalby (Mrs. F. H. Hobler).

The shoulders, although very different to those of *formicicola*, are nearer to those of that species than to those of any other described one, but the parts behind them, the prothorax, punctures, etc., are very different. The antennae on the type are completely immersed in their cavities, so that only the outer face of the basal joint of each is visible. The larger punctures cause a curious small-pox like appearance, especially on the prothorax. The side pieces of the mesosternum project between the elytra and prothorax much as in weevils of the subfamily *Baridiides*. The type was sent in spirits, with many other insects, without comment.

NITIDULIDAE.

Brachypeplus auritus, Murray.

Nearly always to be found in nests of the little native bee (*Trigona carbonaria*) near Sydney.

Brachypeplus basalis, Er.

Seems a fairly common visitor to nests of the little native bee near Sydney; and numerous specimens were once seen in W. Australia about a hive bees' nest in a fallen tree. It is, however, quite a common bark insect.

Circopes pilistriatus, Macl.

A single specimen was taken in a nest of *Camponotus nigriceps*, but it was probably there by accident.

Pria rubicunda, Macl.

Six specimens sent by Mr. Davey as occurring in nests of a "small black evil smelling ant" in a rotten log. I have also seen the species in the company of ants, both in N.S. Wales and Tasmania.

In Masters' Catalogue the species is recorded only from Gayndah, but it is common in many parts of Eastern Australia and Tasmania.

Trogositidae.

A specimen of this family, regarded by Mr. Blackburn as probably belonging to a new genus near *Trogosita*, was taken in a nest of *Pheidole bos* at Mount Barker (W. Australia). Having but the one specimen and the cephalic appendages being very small I have not considered it advisable to deal with it at length. It is, however, a curious insect, with an outline and general appearance much as in some of the narrow black species of *Adelotopus*.

Colydiidae.

Nepharis alata, Cast.

(*Hiketes thoracicus*, King).

Recorded by King from specimens "found in the nest of a large black ant, under a stone at King George's Sound. Messrs. Goudie and Davey have taken it in Victoria from nests of *Iridomyrmex nitidus*.

Nepharis costata, King.

Recorded by King as being "found in the nest of a small red ant living in wood and under bark of dead trees on the ground." Messrs. Goudie and Davey have taken it in abundance from nests of *Iridomyrmex nitidus*.

Nepharis goudiei, Lea.

Occurs in nests of *Crematogaster laeviceps*.

Originally referred with some doubt to *Nepharis*. M. Grouvelle, to whom a specimen was sent, wrote to me that he considered it generically distinct, but I will leave to him the task of proposing a new genus for its reception.

Nepharis serraticollis, n.sp. (Fig. 22.)

Reddish-brown, margins and legs somewhat paler. Without pubescence.

Head flattened, somewhat dilated between antennae, apex notched, a dentiform projection behind each eye, which is small and lateral, with dense and coarse punctures, becoming smaller

in front. *Prothorax* about as long as greatest width, base and apex subtruncate, base slightly wider than apex; margins flattened and strongly serrated; with dense, strong punctures. *Scutellum* minute. *Elytra* very little wider than prothorax, almost parallel-sided to beyond the middle, apex strongly notched, sides with rather narrow flattened margins; regularly (except that the alternate interstices are sometimes feebly raised) cancellate-punctate, in about ten rows, the punctures of almost even size throughout. *Under surface* with punctures as on prothorax. *Femora* very stout; tibiae rather thin but somewhat inflated at apex; tarsi thin. Length 2 2-3rd mm.

Hab.—Victoria: Geelong—in a nest of *Iridomyrmex nitidus* (H. W. Davey).

The antennae are short and indistinctly jointed much as in *goudiei*, so that if it becomes necessary to regard that species as belonging to a new genus, this species should be associated with it. From *goudiei*, however, it differs in being longer and almost twice as wide, with the head of different shape and eyes larger. It has no projecting submentum as in *costata*.

On the type there are thirteen teeth of almost equal size on one side of the prothorax, and fourteen on the other.

Ditoma villosa, n.sp. (Fig. 23.)

Dingy reddish brown, under surface and appendages paler. With numerous long straggling yellowish hairs; under surface pubescent.

Head densely and coarsely punctate, with two feeble tubercles in middle, shallowly depressed between antennae and strongly raised above each antenna, the distance between the tips of the raised parts equal to, or slightly greater than, that between the outer margins of the eyes. *Antennae* about as long as greatest width of head, first joint entirely concealed from above, second slightly longer than third, but from above appearing somewhat shorter; tenth joint slightly larger than eleventh, the two forming a club. *Prothorax* at its greatest width about twice as wide as the length down middle, densely granulate, sides strongly serrated or denticulated; the front angles strongly produced, and also serrated externally. *Elytra* with margins

finely serrated, but otherwise parallel-sided to near apex; with close, regular rows of large punctures. *Under surface* densely punctate. *Legs* rather short; femora stout. Length 3½—3 2-3 mm.

Hab.—Victoria: Birchip, in nests of *Crematogaster laeviceps* (J. C. Goudie); N.S. Wales: Clarence River (G. Compere), Forest Reefs, under a log close to an ants' nest (A. M. Lea).

Several species of the genus are known to have short setae, but on this species the clothing is decidedly long. The teeth on each side of the prothorax vary in number from four to six, exclusive of those (which are usually much smaller) on the produced front angles.

Kershawia rugiceps, Lea.

Occurs in nests of *Iridomyrmex nitidus.*

Both Messrs. Goudie and Davey have sent a bright red larva as belonging to this species. It is of an almost blood-red colour, and subopaque, with the head shining and dark brown, except the muzzle, which is somewhat reddish; on the first thoracic segment there is an infuscate shining M; on each of the two following segments there are two rounded, infuscate, shining spots. The apical segment on its upper surface is shining, the colour of the head, and with two long pale acute processes curved at their apices. Scattered all over the upper surface and sides are some long yellowish hairs; the under surface has much shorter but similarly coloured hairs. The length of a full-grown larva is 6 mm.

Bothrideres tibialis, Blackb.

Mr. Davey informs me that he has taken numerous specimens of this species under the bark of Eucalyptus trees, in the nests of *Colobopsis gasseri.* They were probably there by accident, however.

TRETOTHORACIDAE, n. family.

Antennae ten-jointed, non-clavate. Mentum wide, entirely concealing mouth parts. Metasternum elongate. Four front tarsi five-jointed, the others four-jointed, subapical joint of each not bilobed.

Additional details are given under the generic synopsis. The family at present may be placed between the *Rhysodidae* and *Cucujidae*.

The entire, or almost entire, concealment of the palpi is a character that is not unique in beetles, but so far as I am aware, outside of the *Rhysodidae*, only occurs in myrmecophilous genera.

Tretothorax, n.g.

Head elongate, narrowed behind eyes and strongly constricted at base, sides in front of eyes incurved, and then suddenly inflated at antennae, apex abruptly truncate and without clypeal sutures. Eyes rather large, round, lateral, rather finely faceted, inserted much closer to base than apex. Antennae ten-jointed, short, fairly stout, of almost even width throughout, first joint longer than tenth, this moderately, all the others strongly transverse, apex abruptly truncate. Palpi entirely concealed. Mentum strongly transverse, entirely concealing the mouth parts, front semicircularly emarginate in middle. Gular sutures represented by two short, deep basal grooves. *Prothorax* elongate, deeply grooved both longitudinally and transversely, prosternal sutures deep in front. *Scutellum* minute. *Elytra* long and somewhat depressed, sides gently rounded, and clasping the body. *Mesosternum* fairly long, outer side pieces much larger than the inner, and with deep sutures, the inner not well defined. Metasternum elongate, hind apex notched in middle; episterna very narrow. *Abdomen* long, first segment about as long as second and third combined, second slightly longer than third, third than fourth, and fourth than fifth. *Legs* rather short and thin; front coxae touching, globose, inserted at extreme base of prosternum, and with open coxal cavities, middle coxae slightly larger, but deeply buried and lightly separated; hind coxae still larger, transverse, sides touching elytra, separated internally by a triangular intercoxal process; femora linear, not grooved, edentate, hind pair scarcely passing middle of abdomen; tibiae slightly shorter than femora, terminated by two short stout spines; tarsi linear, not spongiose on lower surface, apical joint slightly longer than first, and first

than any of the others, two first pairs five-jointed, the hind pair four-jointed; claws small and simple. Body winged.

A highly remarkable genus which I have been unable to place in any family by any system of classification I have looked into. Thinking that the Rev. T. Blackburn, with his wider experience, could help me, I sent a specimen to him for his opinion, suggesting that it possibly came close to the *Rhysodidae* or *Colydiidae*, and of it he wrote:—

"One of the most remarkable insects I have seen for a long time past, and not falling naturally into any family known to me. Possibly a new family, but this could not be determined without knowing whether the other sex is heteromerous. If it is I should say that this represents an uncharacterised family (or rather subfamily). If, however (as is probable), this is a male and the female is pentamerous, I should place it in the *Rhysodidae* without much hesitation, and consider it as presenting a character in the tarsi which is by no means rare in the *Clavicornis* (e.g., in *Cucujidae* and *Cryptophagidae*). If, however, it is ♂ of a species with ♀ tarsi pentamerous it would be worthy of note that it is something of the nature of a "missing link" between *Colydiidae* and *Rhysodidae*. You will, of course, remember that these remarks are made without my having examined the under surface. The antennae are certainly as you note, *Colydiiform*, but I should give greater weight to the structure of the tarsi, palpi and pronotum; as far as I can see beneath the head there are some points of analogy with the Passandrides. I think the tarsi are impossible for a *Colydiid*."

Since the specimen mentioned was sent to him I have seen many others (nearly a hundred), and all have the tarsi 5-5-4. Such tarsi are at once suggestive of the *Heteromera*, but they appear to be quite negatived by the apparent entire absence of palpi, whilst the antennae are certainly close to those of several genera of *Colydiidae*, and, as with those, the missing eleventh joint appears to be completely buried within the apex of the tenth. The under surface of the head is not at all like any of the *Passandrides* that I have examined. In the *Rhysodidae*, although the palpi are apparently absent, the mentum is strongly produced instead of emarginate in the middle, and the front coxae are strongly separated instead of touching.

The venation has been of no assistance to me, but as it probably may be to others, a sketch of a wing is given.

Tretothorax cleistostoma, n.sp. (Figs. 13, 14, 49.)

Black or blackish-brown, and rather feebly shining; elytra and under surface usually a trifle paler.

Head more than twice as long as wide; convex and with rather coarse punctures between eyes, a groove close to each eye filled with short dense reddish setae, the same continued, but as a feeble ridge on each side to about the apical third, base with similar but denser setae; between the sublateral setose ridges with a feebly elevated impunctate carina; obtusely semicircularly raised between antennae, and with coarse punctures, becoming smaller, but still distinct, to apex. Under surface with a few coarse punctures, sides behind eyes with setae as on upper surface. Antennae scarcely as long as head, width slightly more than that of front tibiae. *Prothorax* about once and one-half as long as greatest width, sides gently narrowed to apex, and gently towards basal third, thence dilated to near base; with a deep longitudinal groove in middle, and another curved one on each side, the three traversed by a deep groove at about basal third; in consequence each side of the base appears in the form of a raised lobe, obtusely pointed, and almost touching the obtuse point of a longer frontal lobe; the latter with coarse punctures in front, but smooth behind, the basal lobes with a few punctures about extreme base only. *Elytra* narrow but distinctly wider than prothorax, base gently arcuate, sides very feebly dilated to about the basal third, and then feebly narrowed to apex, apex itself feebly notched; with a row of minute punctures on each side of suture, but elsewhere with large dense punctures, rather larger and more rounded towards sides than suture; with short subsutural striae towards apex. Epipleurae rather narrow throughout, each with a regular row of round punctures. *Under surface* with rather dense punctures, rather smaller than on elytra, except on mesosternum and just in front of front coxae, where they are as large. *Legs* densely and rather coarsely punctate, front tarsi with first joint slightly longer than wide, and feebly dilated to

apex, second, third and fourth transverse, and feebly diminishing in size, fifth slightly narrower than fourth, about as long as the first; middle tarsi with the joints, except the fifth, somewhat longer, and only the fourth feebly transverse; hind tarsi with first and fourth joints moderately long; all the tarsal joints (except the claw joint) very feebly grooved on lower surface. Length $8\frac{1}{4}$—$11\frac{1}{2}$ mm.

Hab.—Queensland: Little Mulgrave River, in nests of *Lobopelta excisa*, and of *Odontomachus coriarius* (H. Hacker).

I am unable to point out sexual differences; there is a slight difference in the comparative width across eyes, and between antennae, but these differences are probably individual, rather than sexual. Each puncture of the head and legs contains a short seta. The antennae are rather densely setose. From each side near the base a hole can be seen right through the prothorax, but this is usually filled with mud, on the largest specimens it is just possible for a number eleven Kirby and Beard pin to pass through it up to the head. Mr. Hacker sent two specimens at first as having been taken on a log;[1] later he sent a single one as from the nest of an ant, and still later numerous specimens from nests of two species of ants to Mr. French, who kindly allowed me to examine them.

CRYPTOPHAGIDAE.

Mr. Davey sent a species belonging to this family as from a nest of small black ants. As, however, it was represented by a single specimen of very minute size, and of somewhat doubtful genus, it is not fully worked out at present.

LATHRIDIIDAE.

Holoparamecus kunzei, Aube.

On one occasion numerous specimens of this species were taken from a nest of ants under bark in W. Australia. I have to thank M. Grouvelle for the identification of the species.

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1 He thought they possibly belonged to the *Brenthidae*, and there is certainly a striking superficial resemblance to some genera of that family. And there is even a short groove behind each antenna, almost like a scrobe.

Dermestidae.

Mr. Goudie has seen numerous larvae belonging to this family in ants' nests, but so far has not taken the adult beetles.

Trogoderma socium, Lea.

Originally referred to *Anthrenus*, but, as suspected by Mr. Blackburn, really belongs to *Trogoderma*. Numerous larvae were seen in several nests of a small black ant,[1] but only one adult beetle was obtained.

Byrrhidae.

Microchaetes, sp.

Mr. Goudie and Mr. Davey each sent a single specimen of this genus as from a nest of *Iridomyrmex nitidus;* but they are too badly abraded to be identified with certainty.

Scarabaeidae.

A species of this family, apparently close to *Maechidius*, is represented in my collection by a single specimen that was taken in the nest of a white ant at Swan River. Mr. Blackburn returned it as unknown to him, and as probably not a *Maechidius*. Unfortunately its antennae are badly damaged, so it is not now described.

Maechidius.

Specimens of this genus may frequently be found under bark of Eucalypti close to masses of small black ants, and the ants will often run over them. But as such ants often swarm under such bark and run over many other species of beetles that are certainly not ants'-nest species, probably not much importance can be attached to this. But the appendages of the head are certainly very curiously modified (and protected) in comparison with other *Melolonthides*.

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1 Specimens of ants mounted with the type are badly injured, but evidently belong to the genus *Iridomyrmex*.

Maechidus tibialis, Blackb.

Numerous specimens of this species were seen on one occasion by Mr. Froggatt in galleries of *Coptotermes lacteus.*

Phyllotocus bimaculatus, Er.

An occasional visitor to nests of *Myrmecia pyriformis.*

Cryptodus.

Probably all the species of this genus, at one time or another, resort to the nests of ants, the very curious modification of the cephalic appendages seeming to demonstrate the need of some special protection. They do not appear, however, to be interfered with by the ants.

Cryptodus caviceps, Waterh.

Of this species a pair *in cop.* were taken on top of a nest of the common mound-building ant *Leptomyrmex detectus.* It quite frequently comes to light in S.W. Queensland.

Cryptodus paradoxus, W. S. Macl.

This species may frequently be seen with small black ants[1] under logs, and Mr. Cox has taken it in nests of *Camponotus nigriceps.*

Cryptodus tasmannianus, Westw.

A specimen, apparently a small male of this species, was taken in a nest of *Camponotus nigriceps*, near Sydney, by Mr. W. H. Cox.

Cryptodus variolosus, White.

Common in the coastal districts of W. Australia in nests of a small blackish ant (probably an *Iridomyrmex*) that builds nests of small chips and twigs than can sometimes be set on fire.

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1 Probably a Colobopsis or Iridomyrmex.

Novapus bifidus, n.sp. (Figs. 50, 51, 53.)

♂. Of an uniform reddish-brown, except that the head and some parts of the legs and of the prothoracic margins are black or blackish. Under surface with long reddish hair, becoming lineate in arrangement on the abdomen, pygidium and legs.

Head small, with coarse punctures; in front with three projections, a median one truncate at its tip, and a smaller one about half way between the median one and each eye. With a strong erect horn, slightly longer than head is wide, and distinctly bifid at its apex, punctured as the rest of head at its lower front, but the punctures decreasing in size upwards and becoming very small at the apices. *Prothorax* about once and one-third as wide as long; with an excavation occupying about one-half of its width, its hinder margin evenly curved, but sides almost straight; slightly notched behind head; with rather dense and shallow punctures, somewhat sparser, in excavation than elsewhere. *Scutellum* with punctures only about base. *Elytra* slightly narrower than widest part of prothorax; with punctures somewhat as on prothorax, but sparser and more irregular, and in places in feeble geminate striae; with smaller punctures irregularly distributed, and becoming fairly numerous towards sides. *Abdomen* with dense punctures at sides, but becoming sparse and seriate across middle. *Legs* stout; front tibiae with three strong teeth, the front one rounded, the others somewhat larger and triangular, spur just passing base of front tooth, and about the length of claw joint; middle tibiae with two semicircular ridges tipped with stout setae, in addition to the strong apical ridge, with two stout spurs of uneven size, the shorter as long as the first tarsal joint, the other as long as the two first tarsal joints combined; hind tibiae with somewhat similar ridges and spurs. Length 25, width 14 mm.

♀. Differs in having a much smaller cephalic horn, divided at the tip but with parallel sides, and the punctures coarser. The prothorax is nowhere quite as wide as the greatest width of elytra, the excavation is represented by a very small frontal impression, scarcely visible from some directions, the punctures are more numerous and slightly larger. The elytra have rather more distinct punctures. The abdomen has rather numerous punc-

tures in the middle, and the spur of the front tibiae is smaller and does not quite extend to the base of the apical tooth, and the two hind teeth are less acute. Length 23, width 13 mm.

Hab.—Queensland: Cape York, in a large nest of white ants (H. Elgner).

Close to *crassus*, but cephalic horn of male stouter (except at the base, where it is much thinner), shorter and very distinctly bifid, instead of rather obtusely bilobed (compare figures 50 and 52); prothoracic excavation with parallel sides instead of almost circular in outline (compare figures 53 and 54), the excavation itself with comparatively sparse and more or less rounded punctures, instead of with very dense and more or less transverse ones. The teeth of the front tibiae are also more acute, with deeper notches between them, whilst the spurs are shorter and thinner. The female differs from the female of *crassus* in having the horn larger and bifid, scutellum with punctures on basal half only, front tibiae with larger and more acute teeth, but the spur on each much smaller and less conspicuous. *Crassus* is a fairly common species in W. Australia, where it occurs in the rotting cores of species of *Xanthorrhoea*. *Adelaidae*, described as close to *crassus*, is stated to have the head of the female without a horn; *striatopunctulatus* as with the scutellum densely punctate and prothorax not wider than elytra. The other described species have the cephalic horn simple. Of *rugosicollis* only the female has been described (and it is the only sex known to me), but it also has the cephalic horn simple.

Mr. Elgner saw numerous larvae and pupae in pupal cases in the nest, and sent one of the pupae for examination, in addition to the beetles themselves.

Elateridae.

Tetralobus, sp.

Mr. Elgner has sent a very fine species of this genus as from a large nest of white ants at Cape York, but for want of the necessary literature I have been compelled to leave it unnamed at present.

PTINIDAE.

Several remarkable genera belonging to this family are to be taken in ants' nests, the species occurring sometimes in quite considerable numbers, but usually sparingly. They are all characterised by remarkable antennae and extremely minute palpi, and many have a very large prothoracic fovea. They are all apterous.

Polyplocotes longicollis, Westw.

Occurs with ants.

Polyplocotes nitidus, Westw.

Occurs with ants

Diplocotes howittanus, Westw.

Occurs in nests of ants under bark.

Diplocotes foveicollis, Oll. (Figs. 24, 55.)

Occurs in nests of ants under bark.[1]

Diplocotes niger, v.d. Poll.

I have not seen the original description of this species, but Mr. Blackburn[2] regards it as synonymous with *Diphobia familiaris*, Oll.

Diplocotes armicollis, n.sp. (Figs. 25, 26.)

Dark reddish castaneous, club somewhat paler. Upper surface entirely glabrous; sterna with a median stripe of very short golden clothing.

Head transverse; behind antennae bisinuate; each side of base subacutely produced; densely punctate. Antennae extending to middle coxae, first joint stout, slightly curved, and as long as second and third combined, second slightly longer than third and curved at the base, third to ninth very feebly decreasing in size, tenth slightly longer than eighth and ninth

1 An ant sent with this species by Mr. Davey is very much like *Colobopsis gasseri*, but is somewhat larger, with the abdomen different.

2 Proc. Linn. Soc. N.S. Wales, 1892, p. 300.

combined, base rounded, sides almost parallel, eleventh about half the length of tenth and somewhat narrower, its tip densely pubescent. *Prothorax* slightly longer than wide, each side just before middle produced into an acutely angular tubercle, just behind middle feebly and obtusely produced, and then gently rounded towards base; densely strigose, most of the strigae converging to a large deep fovea, that is nearer base than apex. *Elytra* ovate, strongly convex; with regular rows of rather small and narrow punctures; interstices impunctate, not separately convex. *Abdomen* with first and second segments strigose at sides, the third throughout; elsewhere with somewhat irregular punctures. *Legs* moderately long. Length $1\frac{3}{4}$—2 mm.

Hab.—S. Australia: Adelaide, under bark with ants (H. H. D. Griffith).

Remarkably close in general appearance to *foveicollis*, but with a sharp tubercle or projection on each side of prothorax. In *foveicollis* this projection is rounded or in the form of "an obtuse angle." The present species also has the elytra slightly wider and quite glabrous, instead of sparsely pubescent. The club is slightly compressed, so that from one direction it appears but little wider than the ninth joint, but from another direction distinctly wider.

Diplocotes decemarticulatus, n.sp. (Fig. 57.)

Dark reddish castaneous, elytra, legs and club somewhat paler. Elytra with very sparse and extremely short pubescence, prothorax with a few moderately long thin setae; sterna as in preceding species.

Head and antennae as in the preceding species, except that the antennae are slightly shorter, and with only ten joints. *Prothorax* and *elytra* the same, except that the latter have very minute punctures on the interstices. *Abdomen* densely and finely strigose, except on middle of second segment, where there are a few punctures. *Legs* moderately long. Length 2 mm.

Hab.—W. Australia: Geraldton (A. M. Lea).

Except for a slight difference in colour of elytra, perhaps not constant, it would be practically impossible to distinguish a specimen of this from one of the preceding species, if the

antennal joints were not counted; the extremely curious prothoracic sculpture being identical. The clothing on the upper surface is scarcely perceptible, and the minute punctures on the elytral interstices are very indistinct.

Diplocotes strigicollis, n.sp.

Reddish castaneous; legs and club somewhat paler. With fairly numerous, pale, short, stiff setae, becoming lineate in arrangement on the elytra.

Head as in two preceding species. Antennae extending to middle coxae, first joint stout and very little longer than second, second slightly longer than third, third to eighth equal in width and subequal in length, ninth inflated, subovate, almost as long as three preceding joints combined, tenth slightly narrower and about half the length of ninth, its apex truncate and densely pubescent. *Prothorax* slightly longer than wide; each side just before middle produced into a small acutely angular tubercle, and at basal third notched; densely longitudinally strigose; transversely impressed at basal third, and feebly depressed (but not foveate) in middle of depression. *Elytra* briefly ovate, strongly convex; with regular rows of moderately large but shallow punctures; interstices finely punctate, not separately convex. *Abdomen* densely longitudinally strigose. *Legs* moderately long. Length $1\frac{1}{4}$ mm.

Hab.—S. Australia (type in Australian Museum).

In general appearance like a small setose specimen of the preceding species, and also with ten-jointed antennae, but the club comparatively much wider, and the prothorax with a shallow submedian impression instead of a deep fovea.

The species known to me may be tabulated as follows:—

Antennae ten-jointed.
- Prothorax with a very large fovea - *decemarticulatus*, n. sp.
- Prothorax without such a fovea - - - *strigicollis*, n. sp.

Antennae eleven-jointed.
- Prothorax without a very large fovea - - *howittanus*, Westw.
- Prothorax with such a fovea.
  - Prothorax acutely armed, and elytra glabrous *armicollis*, n. sp.
  - Prothorax obtusely armed, and elytra clothed *foveicollis* Oll.

Ectrephes.

Prof. Westwood referred to this genus two species that certainly appear to be generically different from *formicarum*, its type. In Thesaurus Entomologicus Oxoniensis, plate 3, compare—

Fig 1.—*E. formicarum*, Pasc., with
Fig 2.—*E. kingii*, Westw., and
Fig. 3.—*E. pascoei*, Westw.

It will be seen that the two latter have the prothorax deeply foveate, whilst the first has it without a fovea at all. The antennae also are different.

In *formicarum* and *kingi* the antennae are three-jointed, but the third joint is very different *inter se*. In *pascoei* the antennae are figured as six-jointed, but in the description Westwood says, "antennarum clava oblongo-ovali, depressa, disco supero et infero transverse tri-impresso." The club, according to the figure, is composed of four joints. I believe that the three species should in fact be regarded as belonging to three genera.

Ectrephes formicarum, Pasc.
(*Anapestus kreusleri*, King.)

Taken in ants' nests both in South and Western Australia.

Ectrephes pascoei, Westw.

Described as having been taken under bark, but probably there associated with ants.

Ectrephes kingii, Westw.

Described originally as from Swan River. Mr. Goudie sent me a specimen that was "found in a small black ant's nest in a piece of stick lying on the ground, August, 1908." Mr. Davey captured a specimen at the same time, and it should now be in the National Museum.

Enasiba tristis, Oll.

I have been unable to obtain any additional particulars to those contained in the original description of this species; but

as the genus is allied to *Diphobia* and *Diplocotes*, its only species is practically certain to have myrmecophilous habits.

Paussoptinus laticornis, Lea.

Frequently taken by Messrs. Davey and Goudie in nests of *Iridomyrmex nitidus.*

Paussoptinus brevipennis, Pic.

Recorded from Moora, W. Australia.

Ptinus exulans, Er.

Sometimes occurs in abundance in deserted beehives.

Diphobia familiaris, Oll.

Occurs under loose bark of Eucalypti in company with *Iridomyrmex nitidus.*

Hexaplocotes sulcifrons, Lea.

The type of this species was taken from under a stone in an ant's nest.

TENEBRIONIDAE.

Tribolium myrmecophilum, Lea.

Numerous specimens were taken by Messrs. Davey and Goudie in nests of *Iridomyrmex nitidus.*

Amarygmus termitophilus, n.sp.

Metallic blue or green, scutellum and under surface (the latter in parts obscurely diluted with red) black, appendages red, but five apical joints of antennae more or less black. Glabrous.

Head with dense, clearly defined punctures. Clypeus almost twice as wide as long, basal two thirds with somewhat similar punctures to the rest of head, apical third membranous, impunctate, and almost flavous. Labrum with clearly defined punctures of moderate size, with a few larger ones scattered about. Antennae passing hind coxae, third joint longest of all. *Prothorax* about twice as wide as long, sides strongly rounded; with small dense punctures, the interspaces finely shagreened; with a fine, impunctate, median line. *Elytra*

elongate-cordate, rather more than twice as long as wide; strongly striated, the striae with punctures of moderate size; interstices strongly convex, and with small and fairly numerous punctures; epipleurae smooth, and almost impunctate. *Abdomen* finely wrinkled, second and third segments each with a row of small punctures at the base. *Legs* long and thin. Length 5—6 mm.

Hab.—Queensland: Cape York, in a nest of white ants (H. Elgner); N. Territory, Port Darwin (N. Davies).

The larger or the two Queensland specimens before me has the elytra of a beautiful dark blue colour, from some directions appearing almost purple, but the head and prothorax are more green than blue; as on the smaller specimen; the latter has the elytra much the colour of the prothorax, but from certain directions they appear purplish-blue. Each elytron has a short, oblique subsutural stria, extending for about thrice the length of the scutellum. The elytral interstices are much more convex than in any other small species known to me. The outlines, but scarcely anything else, are much as in *indigaceus*.

Mr. Elgner in forwarding the specimens to me wrote: "In one nest about twelve feet high, when down about half, I noticed these little beetles coming out of the passages of the nest." They probably live with the white ants simply as a matter of convenience. All the fairly numerous specimens of *A. rimosus*, that I found some years ago, were seen in tunnels in citrus trees made by the fine longicorn *Uracanthus cryptophagus*.

CISTELIDAE.

Iophon myrmecophilus, Champ.

Recorded by Champion as occurring in the nests of *Ectatomma reticulatum* under stones.

LAGRIIDAE.

Lagria formicicola, Lea.

Occurs in nests of *Myrmecia forficata* and of a smaller stingless species.[1]

[1] Unfortunately no specimen of the smaller species was kept, but it was about the size of *Polyrachis hexacantha*.

Lagria grandis, Gyll.

An occasional visitor to ants' nests under stones.

ANTHICIDAE.

Anthicus australis, King.

Two specimens, sent by Mr. Davey as from a nest of *Iridomyrmex nitidus*, evidently represent a variety of this species. They differ from the normal form in having the basal joint of antennae much darker (almost black) than the other joints, and the under surface and legs (except that the tarsi are piceous) entirely black. One has the postmedian fascia rather narrower than usual, but from the other it is entirely absent.

Anthicus glaber, King.

Six specimens (two each from three nests) taken near Hobart[1] from nests of *Colobopsis gasseri*. The species was originally recorded from S. Australia without any indication as to its habits. I have also taken it at Tamworth (N.S. Wales) in flood debris.

CURCULIONIDAE.

Tasmanica myrmecophila, Lea.

A minute blind weevil, the first noted specimen of which was taken from under a stone, in the nest of a small red ant. A second dried and discoloured specimen was subsequently obtained under a stone.

BRENTHIDAE.

Cordus hospes, Germ.

Occurs in the nests of many species of ants (including *Iridomyrmex nitidus*[1]) and of several species of termites; and is the only species of its family known to occur in all the Australian States.

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1 Previously unrecorded from Tasmania.

1 Mr. Davey on one occasion found an "immense" number in a large nest of this ant.

Chrysomelidae.

Mr. Davey sent a small species of *Agetinus* as from a nest of *Iridomyrmex nitidus,* but such a typically leaf-eating species was almost certainly there by accident. In sending it he wrote, "This was surrounded by ants, and though not in the nest proper, was roofed over by the ants."

Erotyllidae.

Tritomidea tasmaniae, n.sp. (Fig. 26.)

Black, some parts diluted with red, appendages reddish castaneous; shining and glabrous.

Elliptic, moderately convex. *Head* immersed in prothorax up to the eyes, widely transverse; with rather dense but small punctures; clypeal suture deep on sides, but feeble across middle. Antennae short, club three jointed, its first joint small but distinctly transverse, the others considerably large and more transverse. Prothorax fully twice as wide as long, sides strongly rounded, and very narrowly margined, apex semicircularly emarginate and much narrower than base, the latter with a large scutellar lobe, but outside of this straight to the margins; punctures as on head. *Scutellum* minute. *Elytra* with outlines continuous with those of prothorax, and with similar margins, widest at about basal fourth, thence regularly rounded and decreasing in width to apex; finely striate, the striae with very feeble punctures, and the two on each side of the suture were very feeble; the interstices with small but fairly distinct punctures. Epipleurae moderately wide at the base, becoming very narrow posteriorly. *Prosternum* wide and smooth, hinder apex gently incurved to middle and feebly longitudinally impressed. Intercoxal process of mesosternum about thrice as wide as long. Metasternum slightly longer than two following segments combined, with minute but fairly distinct punctures; episterna very narrow. *Abdomen* with first segment slightly longer than second and third combined, these equal in length, and each slightly longer than fourth, fifth very slightly longer than third. *Femora* rather short and stout; tibiae

rather short, moderately dilated to apex; tarsi thin, apical joint elongate. Length 2 4-5th—3 mm.

Hab.—Tasmania: Hobart, four specimens from a nest of *Amblyopone australis* (R. A. Black), Parattah (A. M. Lea).

The front and sides of prothorax, tips of elytra (and sometimes the suture) head and under surface are more or less noticeably diluted with red; the tip of the abdomen is usually no darker than the legs, of these the tarsi are almost flavous.

The genus, to which this species belongs, is represented by several others in Australia, and for long was an enigma to me. An allied species, from N.S. Wales, was sent some time ago to Mr. George Lewis for his opinion, and he returned it marked as probably a *Tritomidea*.[1] Mr. Blackburn when applied to wrote: "I have this species, and have regarded it as probably an *Erotylid*. I sent a specimen some time ago to Dr. Sharp for his opinion, but unfortunately the box and the enclosed insect were smashed in the post." The majority of the species live in fungi; on my mentioning this to Mr. Black, and questioning his obtaining the specimens in the nest of an ant, he was quite positive that they were so obtained. I do not remember how the Parattah specimen was taken.

Episcaphula termitophila, n.sp. (Fig. 27.)

Black and red, shining. Glabrous, except for some very fine and sparse pubescence on the under surface.

Head about once and one half as wide as long; with dense and distinct punctures, somewhat smaller in middle than elsewhere. Antennae about as long as the width at apex of prothorax, third joint distinctly longer than second or fourth; club about as long as five preceding joints combined, each of its joints strongly transverse. *Prothorax* not twice as wide as long, front angles acute, hind ones almost rectangular; base widely bisinuate; with numerous minute punctures, and with some coarse ones in irregular clusters towards sides, about base and apex. *Scutellum* with minute punctures. *Elytra* widest at about basal fifth, thence regularly diminishing in width;

1. As it seems desirable to include the present species in this paper, I have accepted his opinion as correct; if not a *Tritomidea*, it belongs, at any rate, to a genus not yet recorded.

with rows of very small punctures, but becoming moderately large towards the base in the fourth and fifth rows, and sometimes in the third; interstices with sparse and extremely small punctures. *Legs* rather short and stout. Length 7—7½ mm.

Hab.—Queensland: Cape York, three found together in a large nest of white ants (H. Elgner), Somerset (C. French); Darnley Island (Elgner).

The outlines are much as in *australis*, but the markings are very different. The upper surface of the head is black; the prothorax is red, with a moderately large, irregular, transversely oblong, medio-basal black patch, and the margins narrowly blackish; the scutellum is black; the elytra are black, but each with two large red patches, one subbasal and not quite touching the side and narrowed towards, but not touching, the suture; the other postmedian, and more fasciate in appearance, but not quite touching the side or suture. The under surface and legs are reddish, the former feebly stained in the vicinity of the legs. The antennae are of a rather dark red, with the club somewhat darker.

That such a typically fungus beetle as an *Episcaphula* should be found in a white ants' nest is surprising; but Mr. Elgner also sent larvae of another species as from a white ants' nest, and another species of the family is here recorded as from a true ants' nest.

Var. subapicalis, n.var.

Two specimens (from Somerset and Darnley Island) differ from the typical ones only by having an additional subapical spot on each elytron.

The elytral markings of this variety, although not quite the same, are somewhat as in *nigrofasciata*, but that species is considerably less convex, the seriate punctures on the elytra larger and more regular, the interstices with quite distinct, although small, punctures, and the width at the junction of the prothorax and elytra considerably less.

Corylophidae.

A single very minute specimen, apparently belonging to the genus *Orthoperus*, was taken from a nest of *Colobopsis gasseri* at Launceston.

EXPLANATION OF PLATES XXV.-XXVII.

Plate XXV.

Fig. 1.—Adelotopus celeripes, Lea.
2.—Dabra nitida, Lea.
3.—Dabrosoma pubescens, Lea.
4.—Termophila punctiventris, Lea.
5.—Eleusis nigriventris, Lea.
6.—Glyptoma kingi, Lea.
7.—Plectostenus gracilicornis, Lea.
8.—Articerus cylindricornis, Lea.
9.—Clavigeropsis australiae, Lea.
10.—Scydmaenus microps, Lea.
11.—Phagonophana macrosticta, Lea.
12.—Myrmicholeva ligulata, Lea.
13., 14.—Tretothorax cleistostoma, Lea.

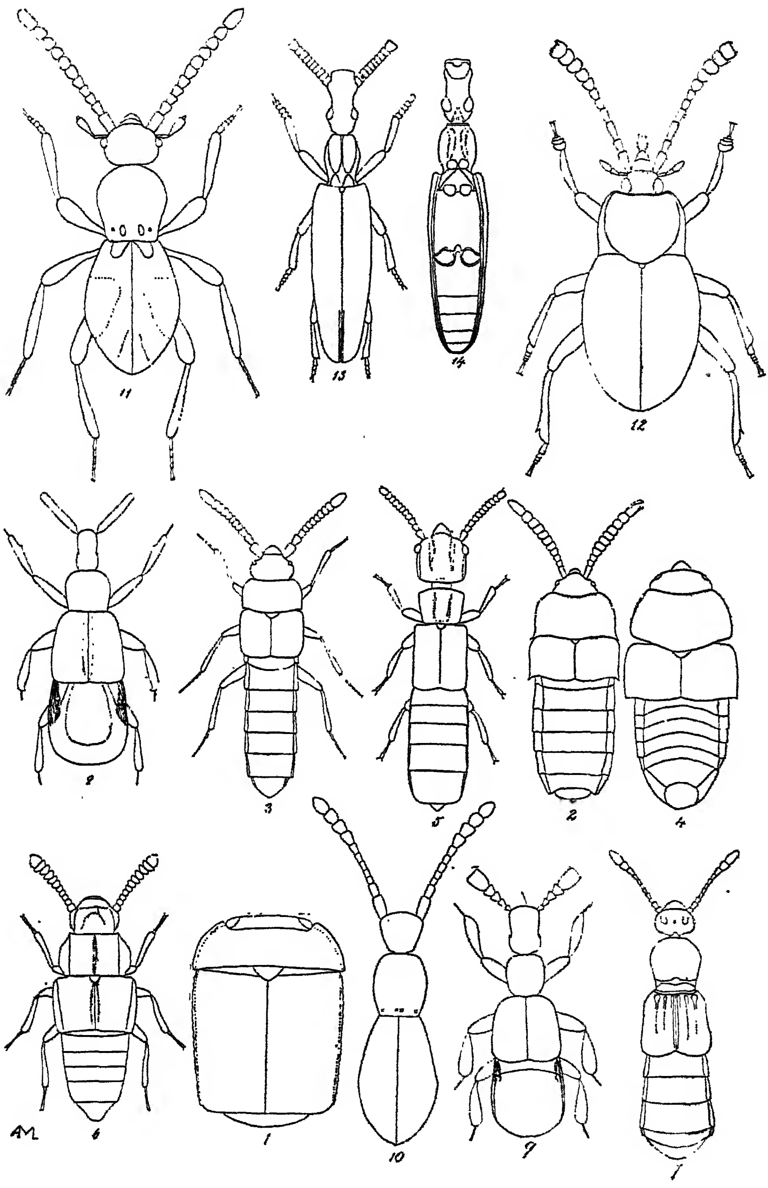
Plate XXVI.

Fig. 15.—Chlamydopsis formicicola, King.
16.— „ „ reticulata, Lea.
17.— „ „ excavata, Lea.
18.— „ „ longipes, Lea.
19.— „ „ glabra, Lea.
20.— „ „ carbo, Lea.
21.— „ „ variolosa, Lea.
22.—Nepharis serraticollis, Lea.
23.—Ditoma villosa, Lea.
24.—Diplocotes foveicollis, Oll.
25.— „ armicollis, Lea.

Plate XXVII.

Fig. 26.—Tritomidea tasmaniae, Lea.
27.—Episcaphula termitophila, Lea.
28.—Prothorax of Polylobus coxi, Lea.
29.— „ „ „ ectatommae, Lea.
30.—Hind leg of Articerus aurifluus, Schfs.

31.—Middle „ „ dentipes, Lea.
32. } Antenna of Articerus raffrayi, Lea; from above and
33. } the side.
34. } Antenna of Articerus dentipes, Lea; from above and
35. } the side.
36. } Antenna of Articerus irregularis, Lea; from above
37. } and the side.
38. } Antenna of Articerus constricticornis, Lea; from
39. } above and the side.
40.—Antenna of Articerus constrictiventris, Lea.
41.— „ „ „ femoralis, Lea.
42.— „ „ „ cylindricornis, Lea.
43.—Prothorax of Myrmicholeva lata, Lea.
44.— „ „ „ „ acutifrons, Lea.
45.— „ „ „ „ punctata, Lea.
46.—Face of Chlamydopsis glaber, Lea.
47.— „ „ „ carbo, Lea.
48.—Side view of prothorax of C. carbo.
49.—Wing of Tretothorax cleistostoma, Lea
50.} Cephalic horns of Novapus bifidus, Lea.
51.}
52.— „ „ „ „ crassus, Sharp.
53.—Prothoracic excavation of Novapus bifidus, Lea. ♂
54.— „ „ „ „ „ crassus, Lea. ♂
55.—Antenna of Diplocotes foveicollis, Oll.
56.— „ „ „ armicollis, Lea.
57.— „ „ „ decemarticulatus, Lea.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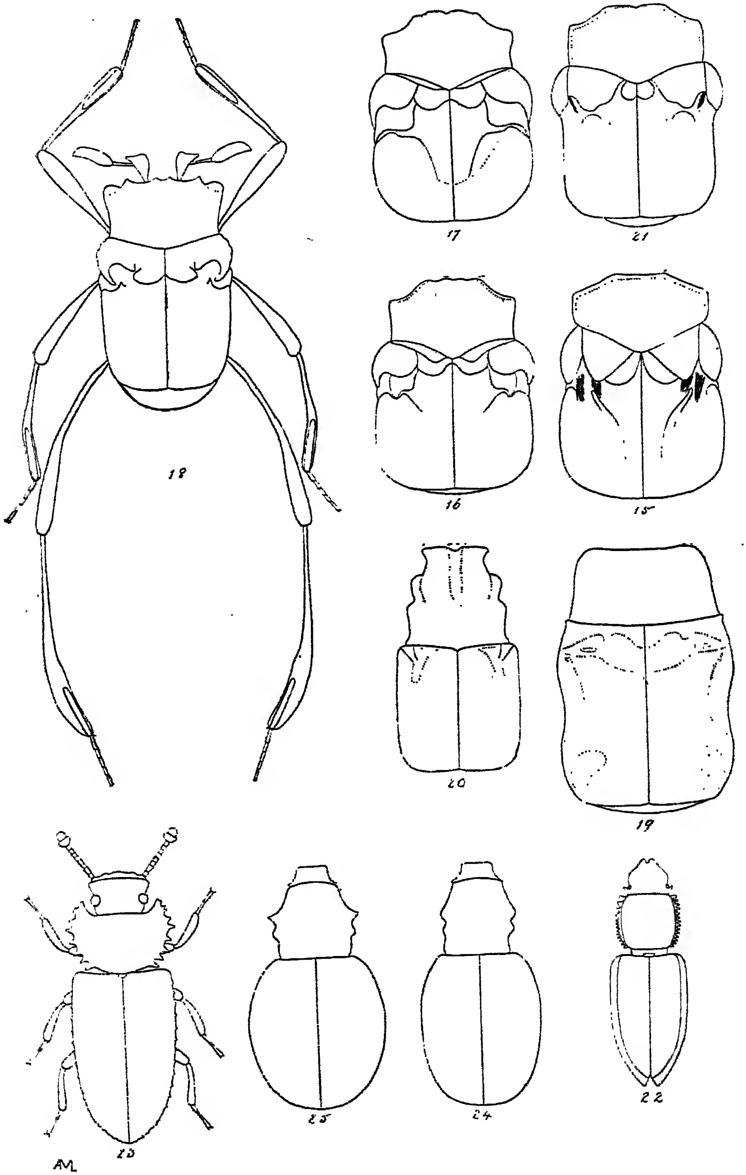

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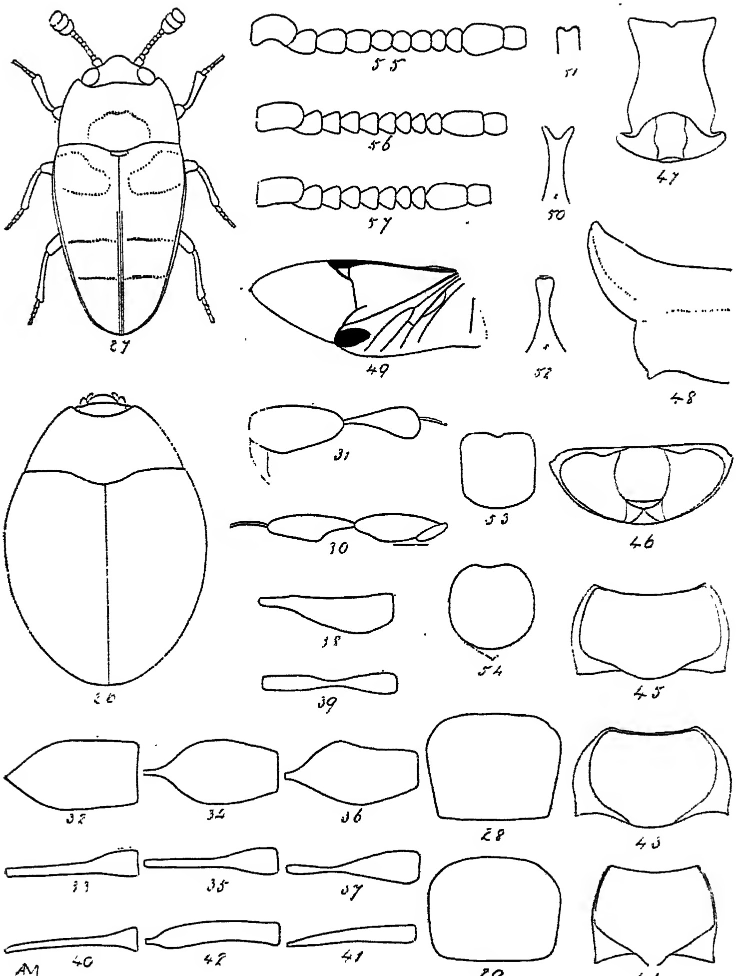
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ART. XXI.—*Notes on Blood Parasites.*

BY

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(With Plates XXVIII.-XXX.)

[Read 14th July, 1910.]

During the past few weeks several interesting Haematozoa have come under our notice, three of which are herein recorded. The specimens of host animals in which these parasites were found were sent to the Veterinary Research Institute, for post mortem examination, from the Zoological Gardens of Melbourne.

1.—Proteosoma biziurae, n. sp.

(Plate XXVIII., Figs. 1–15).

Host animal, *Biziura lobata* (Musk Duck).

So far as we are aware, the only records of Plasmodidae from Australian birds are *Plasmodium praecox (?)* from sparrow (Johnston, 1909, p. 581), afterwards described as *Plasmodium passeris*, Jnstn., by Cleland and Johnston (1909, p. 505).

As regards the generic name adopted for this parasite, we have decided, following Doflein (p. 657) to retain the original generic name *Proteosoma* (Labbé, 1894, p. 157) for those melanin-producing plasmodia of Birds having more or less irregular, round or pear-shaped gametocytes, which when mature distort the erythrocyte and displace the nucleus. On these grounds, *Plasmodium passeris*, Jnstn., should be rather *Proteosoma passeris*. The application of a new specific name to this parasite appears to us to be justified by its apparent dissimi-

larity from other species of this genus, apart from the point that it seems to be the only plasmodial form recorded from the order Anseriformes of Birds.

These parasites were found in two specimens of Musk Duck obtained at different times. Very few cells were affected, so that often none could be seen in many consecutive "fields." The size of the normal erythrocyte is 13.5 to 14.2 μ long by 7.8 to 8.5 μ wide. The parasite varies in size from 8.5 to 10 μ long by 4.8 to 9.7 μ wide in apparently fully-developed forms, thus causing an increase in size and a distortion of the infected erythrocytes, which may reach 15.6 μ long and 9.7 to 10.6 μ wide in size, and become irregular, pyriform, polyhedral, or spherical in shape.

Both young forms (cf. Figs. 7, 8 and 12) and mature gametocytes were found (cf. Figs. 3, 9, 13, 14 and 15). In the young parasites which are elongated, e.g., Fig. 7, no nucleus could be seen, but numerous fine granules of pigment are present. Later, as in Fig 8, large melanin-pigment granules appear, this figure also illustrating their occasional triangular form. In the one shown in Fig. 12, a small well-defined vesicular nucleus can be seen. The later stages show a gradual approach to the spherical form found in the mature parasite, e.g., Figs. 3, 9, 13, 14, 15. With the increasing size and more spherical form of the parasite, the nucleus of the host-cell becomes displaced from the centre and pushed more or less to one end or side. In the former case, the direction of the long axis of the nucleus is changed, and it comes to lie obliquely across the length of the erythrocyte much in the same way as happens in the host-cells of *Proteosoma praecox.* No bean-shaped or gregarinoid forms similar to those in *P. praecox* could be found, unless the form shown in Fig. 6 may be so regarded. The spherical shape of the gametocytes reminds one of those of *P. passeris*, but the parasites of the Musk Duck are larger than those of the sparrow, being really intermediate in size between *P. vaughani* and *P. passeris* 5 to 6.5 μ), and P. majoris (11 to 12 μ).

Both male and female gametocytes are present, but no sporulation stages could be found. The male gametocytes are represented by Figs. 14 and 15, in which the body of the

parasite, which is oval, is more hyaline, the nucleus very diffuse, and the melanin pigment granules disposed at either pole.

The fully-developed female gametocytes (Figs. 3, 9 and 13) show a spherical outline, a more granular body, a more or less general distribution of the large melanin granules and a more definite clear nucleus, except in Fig. 3, in which no nucleus could be detected at all. No erythrocytes could be found in which the parasite had occasioned the loss of the host nucleus; nor were any free forms to be found except that in Fig. 10, in which the body was hyaline with a faintly staining diffuse nucleus near the broader end, and the partly free much more coarsely granular form in Fig. 5. Five typical forms may be described as follows:—

1. The nucleus of the red blood corpuscle is pushed close to the edge, there being little cytoplasm in the host-cell, the greater portion of which is occupied by the parasite. The latter has a very slightly eccentric homogeneous nucleus staining pink (with Giemsa's stain), the finely granular protoplasm staining a deep blue. The body contains irregular but evenly distributed fine pigment granules. No limiting membrane was present (cf. Fig. 9).

2. The nucleus of the host-cell which contains a large amount of protoplasm is pushed to one side. The parasite has a large pink-stained nucleus almost filling the body with faint blue protoplasm at either side, containing fine granules (cf. Fig. 15).

3. Host-cell is not always enlarged, but the nucleus is pushed to one side; the parasite is very faint and pinkish throughout. Large granules are distributed more or less generally. No distinct nucleus is to be seen. Definite limiting membrane is present (cf. Fig. 4).

In such as shown in Fig. 6, two vesicular nuclei are seen within a very granular protoplasmic body.

4. The host-cell is enlarged and somewhat pyriform. The nucleus is slightly displaced by the oval parasite, which has a diffuse pinkish sometimes eccentric nucleus, in a bluish body, more deeply stained at one extremity. The pigment granules are irregular, but more or less polar in distribution (cf. Fig. 14).

5. The host-cell is more markedly pyriform, and the nucleus much displaced. The parasite has a spherical pinkish finely granular body with no defined nucleus and coarse granules scattered throughout (cf. Fig. 3. Fig. 13 is similar, but shows a slightly defined, small, eccentric nucleus in the parasite, which occupies a more oval host-cell).

2.—Haemogregarina megalocystis, n. sp.

(Plate XXIX., Figs. 1–12).

Host animal *Python spilotes*, var. *variegata*.

As will be seen this reptilian parasite is to be regarded as belonging to the genus *Haemogregarina* (s.s.) (cf. Doflein p. 681-2) rather than *Karyolysus* since the atrophied nucleus associated with the presence of the latter is absent here, although a degeneration of the stroma of the host erythrocyte is present somewhat comparable to that found in the case of *Karyolysus lacertarum*.

The blood smears taken from this host showed very many of the red blood corpuscles to be affected with haemogregarines, two or three in one "field" not being uncommonly seen, while in one chance "field" 1.1 mm. in diameter, 10 such infected erythrocytes were counted to about 600 normal corpuscles.

The infected host-cells are always enlarged, being generally two to three times the normal size, though so far as we could find not more than one parasite is present in each. The cytoplasm of the host-cell is extremely tenuous, and in the larger forms is completely dehaemoglobinised, so much so that when overlapping another corpuscle little or no obscuration can be detected. In the less enlarged host-cells, the dehaemoglobinisation is proportionately less noticeable, the staining in the former case showing very faintly purple, against the distinct red of the normal erythrocyte. The nucleus of the host-cell is distinct often displaced towards one extremity, or to one side, and rarely lying on the convex borders of the parasite. The influence of the parasite on the host-nucleus is seen not in atrophy, but in its longer, and rarely narrower, sometimes wider outline, while it stains much more deeply and more

homogeneously than do the unaffected nuclei. The size of the normal erythrocyte varies from 15.2 μ long by 3.7 μ wide to rarely 21.3 μ long by 4 μ wide. That of the infected cells varies from 22 μ long by 14.2 μ wide up to 60 μ long by 28 μ wide, 35 to 55 μ being the more frequent lengths by about 20 μ in width. The parasite itself lies in the central region of the host-cell alongside the host-nucleus. It is gregarinoid in form. In size it nearly always exceeds that of the host nucleus, and often that of the majority of the normal erythrocytes. Thus it varies from 13 μ long by 4 μ wide up to 18.6 μ long by 5.6 μ wide, 14 to 16 μ in length by 5 μ in width being the more frequent. All forms seen were sporonts, no forms showing the division stages of the sexual cycle being found. The body is fairly homogeneous, somewhat granular and blue (with Giemsa smears) often fainter at one extremity than elsewhere. The nucleus is generally spherical, pinkish with deeper stained almost reddish granules, sometimes distributed chiefly in a radial manner at the periphery, but often fairly regularly throughout the nucleus. It may be central, but at times lies towards one extremity. The capsule of the parasite is rarely seen (cf. Figs. 3, 4 and 10), but often the whole parasite, whether capsule is present or not, is seen surrounded by a faint zone, limited by a definite thin line, which appears to enclose the nucleus of the host-cell as well as the parasite. Doubtless this area represents an area of degenerated stroma similar to that shown in the case of *Karyolysus lacertarum*, though in this case no granulation is observable. The curious appearance of the host nucleus shown in Fig. 7, a blue-stained, kidney-shaped mass surrounding a pink homogeneous centre, together with the degeneration of the stroma, in other forms is certainly suggestive of an affinity with *Karyolysus*. The hooked tail of the homogregarinoid form is well seen in Fig. 11, in which also the host-cell nucleus is markedly enlarged and altered in shape. In rare cases enlarged cells were found, such as shown in Figs. 9a and 9b, in which no parasite was visible. It is improbable that these are cells which have been vacated by a parasite, since they are not fully enlarged, and are normal except in size and in the enlarged nucleus. Fig 8 shows a curious appearance found in

a leucocyte, in which a deeply-stained, rosette-like mass of chromatin (?) was present close beside the normal leucocyte nucleus. The condition of the host-cells here is somewhat comparable to that found by Sambon (1907 p. 284) in *Coluber corais* var. *couperi*, though he does not mention any such degeneration of the host stroma; and further the bean-shaped forms of *H. rarefaciens*, Sambon, are considerably smaller than many of those met with here. Moreover the parasite in *H. megalocystis* (n.sp.), so far as we could find, does not show any of the long narrow forms found in *H. rarefaciens*, and unless Fig. 8 represents some stage of the former, we could find no parasites in the leucocytes of this specimen of *Python spilotes* var. *variegata*. In view of these differences from Sambon's form, and of the different families of the hosts, we feel justified in the meantime in regarding this as a new species.

The blood of this specimen shows large numbers of short bacilli, with distinct capsule, often in long chains, and sometimes sporulating; they were isolated, and grow readily in ordinary media.

3.—Microfilaria gymnorhinae, n. sp.

(Plate XXX., Figs. 1–3).

Host animal—*Gymnorhina tibicen*.

Up to the present no blood-filariae appear to have been found in the birds of Southern Australia, though adults of *Filaria tricuspis*, Fedtsch, have been recorded from 3 birds belonging to the Bismarck Archipelago to the North of Australia (Von Linstow, 1897, p. 283), of *Filaria flabellata*, Von Linst., and *Filaria paradisea*, Von Linst., from *Paradisea apoda* from the Aru Is., also lying to the North of Australia (Von Linstow, 1888, pp. 9-11); *Filaria* spp. from the "blood, peritoneal cavity, muscles of thigh and pericardium of 15 birds," including the magpie, *Gymnorhina tibicen* (Bancroft, 1889, p. 58); *Filaria* sp. from *Centropus ateralbus*, Less., and Filaria sp. from *Ninox odiosa*, Scl., from the Bismarck Archipelago (Von Linstow, 1897, p. 284).

In the present case, we have found filariae in the blood of 8 magpies (*Gymnorhina tibicen*) which died at the Melbourne

Zoolog'cal Gardens, an interval of 6 days passing between the first and second lots, and over a week between these and the last lot. They were comparatively numerous in all 8 birds, especially so in one, and were present chiefly in smears from the heart-blood, kidney and liver. They were found living and motile up to more than 45 hours after reaching us, in a liver which had been kept after reception in physiological saline. This is in marked contrast to the statement by Bancroft that "immediately after the bird is shot is the proper time to examine the blood . . if the bird is left for 6 or more hours it is difficult to find them, and after 30 hours impossible. The worms soon die and are then quickly dissolved." It is more in harmony with what Von Linstow (1891, p. 302) found in the case of the Filaria of the crow, viz., that the larvae lived for 48 hours after the death of the bird. None of our specimens were seen by us till some hours after their death.

Bancroft (1889, p. 59) assumes that the intermediate host of the filaria which he found in these fifteen species of birds, including several crows, would be the lice of the bird, since on the Blue Mountain parrot he had noted the occurrence of a blood-sucking louse. This is somewhat at variance with the opinion expressed by Von Linstow, that the crow becomes infected directly by eating the infested entrails of dead birds (Von Linstow, 1891, p. 303). No other parasites, either external or internal, could be found on these birds, several of which were most carefully examined for this purpose. The absence of adult filariae from all these specimens is, perhaps, not to be wondered at since Dr. Bancroft, after an evidently very careful search, found them in not more than 6 individuals out of 112 birds, and 3 out of "a large number."

As to the general condition of the birds, 2 were in fairly good condition, though the others were extremely thin, otherwise appearing healthy.

No indications were present as to the cause of death of the birds, other than the presence of these filarial larvae, though in the light of their presence in so many birds apparently shot, as shown by Dr. Bancroft, their pathological effect cannot be regarded as certain. As will be seen on reference to the figures, 3 types of larvae are present. Whether they represent different

stages of the same species of parasite, as one might assume, is at least questionable since the larger forms are markedly less differentiated in character than the smaller forms. That they are not due to differences in method of fixing or staining is evident from the frequency with which the two dissimilar forms are met on the same slide, and even almost alongside each other. Further, many of the smears were made from blood or organs containing living larvae. These different forms were met with in all the smears, No. 2 being much the least frequent.

No. 1.—Elongated and cylindrical, with a bluntly rounded head end, and a bluntly tapered tail. Generally 98 μ long by 4.5 μ wide, i.e., rather less than a red blood corpuscle in diameter. The head is hyaline for 5.6 μ long, showing only 2 nuclei on one surface, deeply staining blue with Giemsa, and behind this a row of large, clearer, more homogeneous nuclei faintly stained pink. The bulk of the body is ocupied by a series of deeply staining (blue) nuclei which appear to form the periphery of the cellular body, and to enclose a longitudinal series of pink-stained nuclei similar to those described above, though rather smaller, presumably the future alimentary canal. At the point marked 2 in Fig. 1, these or rather larger similar nuclei form a group of cells. The embryonic sheath was not visible, but the clear colourless external body-wall can be seen sometimes to show minute transverse striations such as those described by Manson in *Filaria bancrofti*, var. *nocturna* (Manson, p. 550).

The clear spot, Manson's "V-spot," found near the head end in some other filarial larvae, does not appear to be present as such here. At the points marked (4) and (5) two small irregular "breaks" in the line of nuclei can be seen. At the point marked (1), 1-7th of the length of the body from the tail end, the well-marked "tail-spot" is visible, while at (3) a sharply defined diamond-shaped clear area is visible which does not seem to be represented in exactly the same place in other filarial larvae. It is 5 μ long.

No. 2.—This is the least frequent of the 3 types, and shows a much sharper and less hyaline head. The body generally is a very faint blue with less deeply stained, more pinkish nuclei than in No. 2. Rarely the "pink nuclei" (which are much less

distinct here) in the centre of the body, are seen to be arranged in an irregular double line, especially in the head region. The gaps corresponding to 1, 3 and 4 in No. 1 are present, but in somewhat different positions in the length of the body. In the place of the special group of nuclei marked 2 in Fig. 1, there is occasionally a clear round pink spot surrounded by a deep blue zone. This form of larva is generally 108 μ long by 5.6 μ wide.

No. 3.—The third type of larva, as shown in Fig. 3, is very much less differentiated than either of the others, and though much more frequent than No. 2, is less so than No. 1. The head is sometimes hyaline, sometimes not, the tail is much more pointed than in either of the other types. Only one clear spot is visible, presumably the tail spot (No. 3). No difference in character or arrangement can be detected in any of the nuclei, the whole of which stain much more deeply than those of Nos. 1 and 2, giving this form a distinctly darker blue colour as compared with the other larvae.

In length these vary from 112 μ to 126 μ long (very rarely to 136 μ), and are 4.5 μ wide, i.e., narrower than type No. 2. The tail spot is generally about 3-8th of the body length from the tip of the tail.

In none of these larvae could the sheath be definitely determined.

As will be seen (Von Linstow, 1891, p. 301-2), these larvae are all distinctly smaller than those observed by Von Linstow in *Filaria tricuspis*, and by Borell in the crow, but are not unlike in size those described by Ecker and Herbst in several species of crow, as larvae of *Filaria attenuata*. It is not unlikely that the present form may prove to be one or other of these species, but in the meantime the name of *Microfilaria gymnorhinae* is used for facility of record.

EXPLANATION OF PLATES XXVIII.–XXX.

All figures drawn under obj. 1/12 oil-immersion, oc. 4, with camera lucida.

PLATE XXVIII —PROTEOSOMA BIZIURAE, n sp

Figs 1 and 2—Normal erythrocytes
3, 9 and 13 (and ? 4, 6, 11)—Female gametocytes
7 and 12—Young plasmodia
14 and 15—Male erythrocytes
5—Parasite leaving erythrocyte (?)
10—Escaped parasite, with diffuse nucleus

PLATE XXIX —HAEMOGREGARINA MEGALOCYSTIS, n sp

Figs 1a to 1d—Normal erythrocytes
2, 5, 6—Infected erythrocytes, showing degeneration of stroma but no capsule
3, 4, 10—Infected erythrocytes, showing degeneration of stroma (ill-defined in No 4) and capsule of parasite
7, 11—Infected erythrocytes, without any degeneration area Parasite not encapsuled
11—Shows abnormally hypertrophied nucleus, but normal stroma
8 —Leucocyte, showing chromatin rosette
9a, 9b —Hypertrophied erythrocytes, containing no parasite
12 —Erythrocyte, normal except in shape and more faintly staining nucleus

PLATE XXX —MICROFILARIA GYMNORHINAE, n. sp.

Figs 1 to 3—Showing 3 types of larvae.

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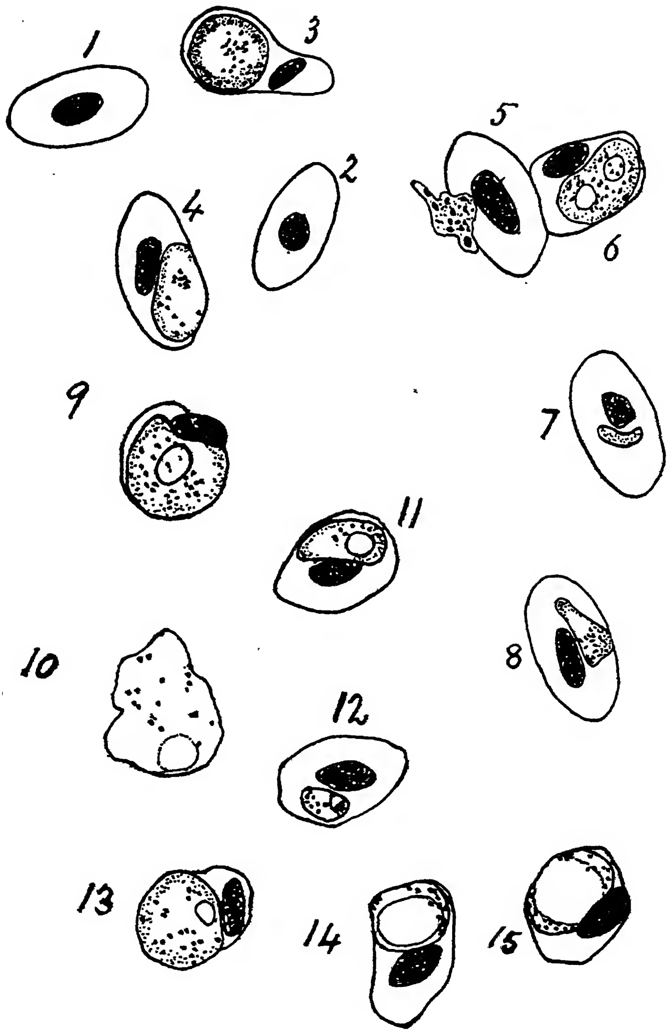
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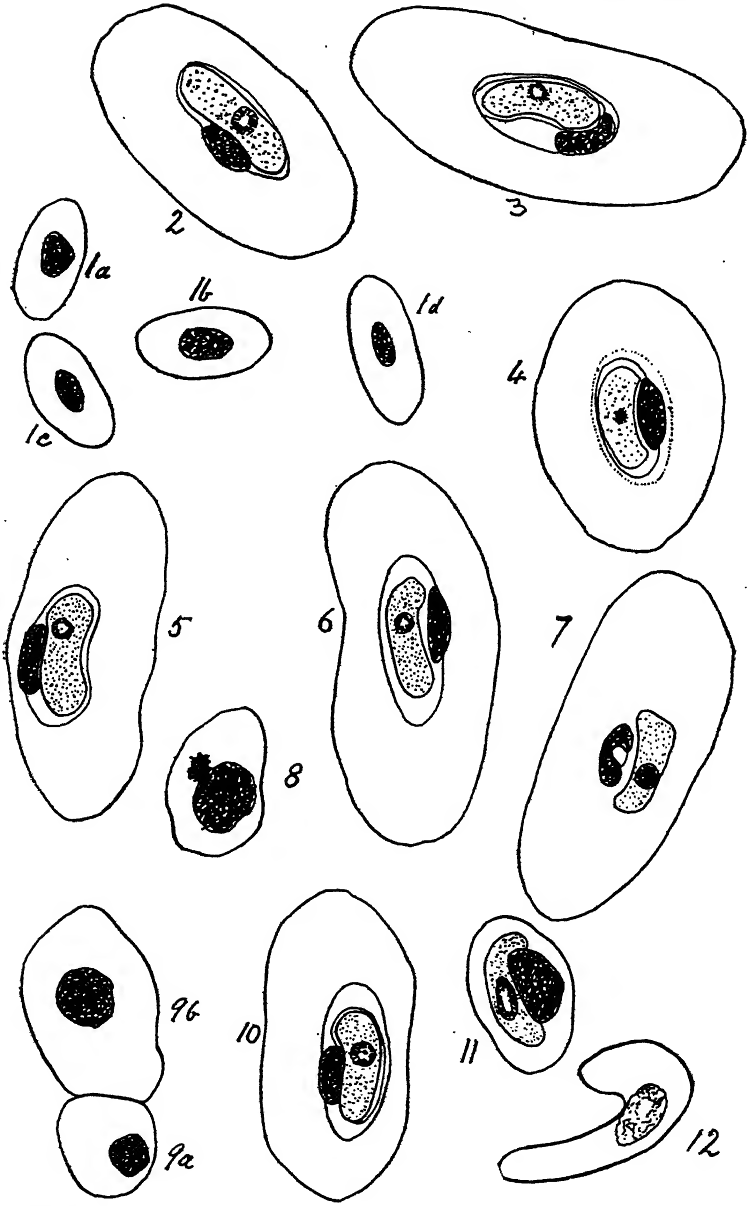

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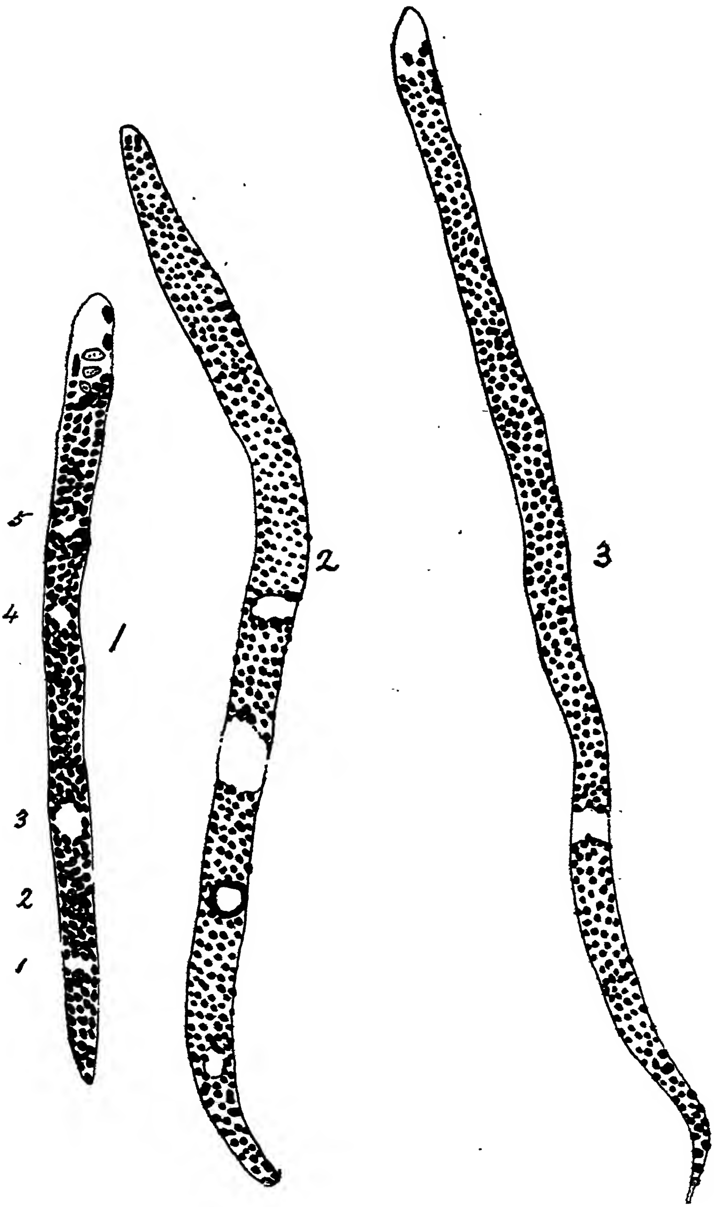

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Art. XXII.—*Some New and Unrecorded Endoparasites from Australian Chickens.*

By GEORGINA SWEET, D.Sc. (Melbourne).

(With Plates XXXI.-XXXV.)

[Read 14th July, 1910.]

Some time ago Professor Gilruth, as Director of the Veterinary Research Institute of the Melbourne University, handed me a small phial containing "tapeworms from fowls," with a request for their identification and report. Since then I have collected endoparasites from a number of chickens from Victoria. The following contains the results of these observations, together with the record of two forms sent from Queensland fowls by Dr. Sydney Dodd, Chief Veterinarian and Bacteriologist, Brisbane, and of one from Dr. H. Cumpston, Chief Health Officer, Perth, West Australia.

CESTODA.

Choanotaenia infundibulum (Bloch, 1779), Cohn, 1899.

This cestode appears fairly common in the suburbs of Melbourne, and has not been previously definitely recorded from any part of Australia.

My specimens of this species show in over 60 per cent. of cases a somewhat smaller diameter of the head, viz., .33 mm., and sometimes even less (.31 mm.) instead of the normal .4 mm. The head seems always conical. The suckers are generally .17 to .22 mm. long, and .068 mm. in transverse diameter; the rostellum has a rather greater width than usual, viz., .08 to .1 mm., while the hooks it carries vary in number from 11 to 22, have the characteristic shape, and are .024 to .03 mm. long.

Davainea cesticillus (Molin, 1858), Blanchard, 1891.

This cestode of fowls has been previously recorded for Australia, only from New South Wales, by Mr. T. H. Johnston

(1909, p. 590). My specimens are all from the suburbs of Melbourne.

Davainea tetragona (Molin, 1858), Blanchard, 1891.

This cestode also has only been previously recorded for Australia by Mr. Johnston (loc. cit.) from New South Wales. My specimens were sent by Dr. Dodd from Rockhampton, Queensland. I have not, so far, been able to obtain any specimens from Victorian chickens.

Davainea varians (sp.n.) (Pls. XXXI.-XXXIII., Figs. 1-13).

This new species I have so far only found amongst those handed to me by Professor Gilruth, from one of the outer eastern suburbs of Melbourne. At first glance it will almost certainly be identified with *Davainea proglottina*, and it is only on close examination of the head with its rostellum and suckers—the characters of which are often extremely difficult to see—and also of sections of the body, that one is convinced that this cannot be that species. In different respects it suggests a combination of some features of *D. proglottina* with others of *D. echinobothrida.*

The specific name has been given in reference to the great variability in the conformation of the strobila, some of the variations in which are given herewith (Figs. 3 to 7), as drawn with the camera lucida.

Description.—Strobila .7 to 1.8 mm. long by .33 to .68 mm. broad. Head club-shaped to globular or spherical, .07 mm. to .155 or even .217 mm. long by .1 to .19 mm. broad. The neck, which is often hardly present at all, may be up to .092 mm. long, and from .059 to .11 mm. wide (only rarely the former). The retractile rostellum is broad and much depressed; its antero-posterior diameter varies from .009 and .016 (completely everted) to .026 mm., and its lateral diameter .044 (and once .033) mm. to .075 mm. The middle region of the fully everted rostellum carries a row of hooks .0075 to .009 mm. long. These hooks, 44 to 50 in number, though not varying much in length, are arranged in an alternating manner (as shown in Fig. 1). The shaft or prong is bar-like, nearly straight, in the middle two-thirds, but when seen in face view cuneate or broadly wedge-

shaped at the tip, and in side view bent dorsally. The dorsal root is short, the ventral long, curved and pointed (contrast the rostellar hooks of *D. proglottina*). The suckers are circular, .033 to .046 mm. in diam. (rarely the latter), and are armed with 4 or 5 (or rarely 6) rows of thorn-like hooks, .005 in length, with a more or less clearly bilobed base, formed by the two roots, which are almost equal in length. These hooks become very easily detached from the suckers (as shown in Fig. 1). The strobila has in addition to the head from 4 to 6 segments, the shape of which varies greatly. The first may be only .045 mm. long, and the last may be .29 mm. (in a strobila of .7 mm. length) to .79 mm. (in a strobila of 1.32 mm. length). The shape of each individual segment being much wider than long (e.g., in the proportion of 4 or 6 to 1), may be such that the whole strobila is like a low cone with a rounded base; or, all the segments except the youngest, from being equal in length and breadth, may become at the posterior end 1½ to 2½ times as long as they are wide. The head becomes very easily detached from the first segment, and that from the second segment. Genital pores are alternate, and situated at or near the anterior angle, sometimes on a low papilla. The stage of development reached by the female genitalia in relation to that of the male in the individual segments varies in different individual strobilae. Thus in some cases a condition somewhat similar to that found in *D. proglottina* is to be seen, i.e., the last segment contains only the eggs with the oncospheres. The next younger segment contains well-developed female organs, often with fully-formed eggs, and the more or less atrophied male organs, while in the next younger segment still, the female reproductive organs are somewhat more developed than in the corresponding segment in *D. proglottina*. Two variations from this condition are found. In the one the male organs appear to be functional as far back as the fifth or last segment (e.g., Fig. 8), the female organs being much less developed than in corresponding segments of other strobilae. In the other variation hardly any sign even of atrophied male organs can be seen in any of the segments, the eggs being well developed as far forward as the third segment. Evidently there is a considerable difference in the degree of protrandry shown in different individual strobilae.

The cirrus pouch is more globular than in *D. proglottina*, and the contained cirrus, which is armed with spines, may be extruded to a length of .148 mm. from the body. The eggs are more or less isolated, the parent parenchyma being arranged so as to form thin fibrous capsules with a membrane enclosing the eggs singly or in groups of two to (rarely) thirteen; the ova are .018 to .020 mm. in diameter. Egg-capsules containing two ova may be .0325 to .050 mm. in extreme length. Hooks of the oncosphere .006 to .008 mm. long.

The histological details of these specimens were extremely hard to make out, owing in great measure to the number of large yellowish concretions up to .012 mm. by .0078 mm. in size. The cuticle is .004 to .006 mm. in thickness.

The life-history is unknown.

The variations met with in the general shape of the strobila, and in the relative stage of development reached by the two sets of reproductive organs, in the individual segments, suggest the possibility of there being two species represented in this material, but I have been unable to detect any differences of specific value, and hence can only regard this as a very variable form, probably undergoing evolutionary development from the Northern Hemisphere form, *D. proglottina*, into one or two more new species.

With regard to the condition of the hosts, I have received the following note from Professor Gilruth:—"The parasites were found in two chickens, each a few months old, which were received at the laboratory for examination, from the suburbs of Melbourne. One was a pure Orpington, the other a Plymouth Rock. Both fowls were suffering from diarrhoea, and were emaciated. On post mortem examination the posterior half of the duodenal loop was found to be affected with muco-enteritis, the contents being of a whitish mucoid nature. Amongst this material were a large number of minute parasites, apparently a small species of "Taenia," also two or three larger cestodes. The intestines of both chickens were congested, but in one they were empty, while in those of the other, the "Plymouth Rock," there was a large quantity of the mucoid material present, similar to that noted in the duodenum."

The larger tapeworm here associated with *D. varians* was *D. cesticillus*.

NEMATODA.

Heterakis perspicillum (Rudolphi, 1803), Schneider, 1866.

This was found in the small intestine of 25 per cent. of the fowls examined from Victoria, and then not above 20 to 50 in number. It is also represented in my collection by a few specimens sent by Dr. H. Cumpston, from West Australia. It is already known from New South Wales (Cobb, 1896, p. 747; and 1898, p. 316), and Johnston (1909, p. 412), and "in ovo" (Cobb, 1905, p. 561). Probably also the *Ascaris* sp., reported from New South Wales by Perrie (1892, p. 821), was this species.

Heterakis papillosa (Bloch, 1782), Railliet, 1885.

This nematode appears to be common, as is usual in other countries, in the fowls around Melbourne—practically every fowl examined having at least a few of these worms in either small intestine, rectal caeca, or rectum, while in some cases they were very numerous.

This has previously been recorded for Australia by Cobb (1896, p. 748), and Johnston (1909, p. 412), from New South Wales only, though it is probable also that the *Oxyuris* sp. recorded from New South Wales by Perrie (1892, p. 822) was this species.

Aff. *Heterakis maculosa* (Rudolphi, 1802), Schneider, 1886.

Among the specimens of *H. papillosa* taken from the rectum and caeca of a fowl are 3 imperfect male specimens of some form of *Heterakis*, which does not exactly fit into any of the known species of that genus.

The body, which is 12-13 mm. long, is thick and very transparent, sharply tapering anteriorly and only slightly posteriorly. The mouth is surrounded by three very well-marked lips, the superior being slightly the largest, and each lip has a papilla in the centre of its base. No lateral wings are visible on either

head, sides or tail. The tail is truncated obliquely, and has a mucronate tip. It carries, so far as these specimens show, only 3 pairs of post-anal papillae. There are two spicules, short, and not quite equal. The preanal sucker has a strongly developed chitinous ring.

In some points it appears most closely allied to *Heterakis maculosa* of the pigeon and pheasant, but it is smaller, apparently has fewer anal papillae, and has no lateral wings at the anterior end.

The imperfectness of the present material, which I have not been able so far to augment, precludes me from giving a fuller account of this form. *H. maculosa* itself has not, so far as I am aware, been recorded from the fowl.

Trichosoma retusum, Raill., 1893.

This form was only found in one case, fairly numerous, in the small intestine of an apparently perfect bird.

The specimens are normal except that the female may reach a length of 30 mm. (as against 19 mm.), and the eggs are 45 to 65 μ long by 18 to 24 μ wide (as against 50-55 μ long by 30 to 32 μ wide).

This genus has not, so far, been recorded from the fowl in Australia. My specimens are from the neighbourhood of Melbourne.

Oxyspirura parvovum (sp.n.). (Pls. XXXIII.-XXXV., Figs. 14-21).

The 16 specimens on which this description is based were sent to me from Rockhampton, Queensland, by Dr. S. Dodd, to whom I am also indebted for the accompanying note on their manner of occurrence and effect on the host.

Description.—The body tapers gradually to each end, the anterior end being bluntly rounded, the tail tapering more sharply. The outer layer of the cuticle has very fine transverse striations, and occasionally faint longitudinal ones also, which are finer than those due to the polymyarian structure of the muscle-layer.

Sometimes, as in four out of seven specimens, the male has swollen cuticular "wings" anteriorly on either side of the head

(see Figs. 16 and 17). They commence at various distances, .034, .06 and .18 mm. from the anterior end, and extend backwards for .09 to .129 mm., attaining a maximum width of .03 mm. They seem to be always uneven, both in their anterior boundary and in length on the two sides. These are presumably comparable with the "voluminous lateral cuticular membranes" given by Ransom as characteristic of *O. anacanthura* (1904, p. 21) and the "bladder-like expansion" of *O. brevisubulata* (Ransom, 1904, p. 23).

In the form now being described, although these structures are not constant in their full development, other male specimens in addition to those mentioned above show a tendency towards the lateral expansion of the cuticle at points varying in position on the head region. When these cephalic wings are largest the body is always constricted in the region over which the "wings" are present (cf. Fig. 16).

The mouth is somewhat oval, and is surrounded by 6 small oral papillae, 4 submedian and 2 lateral, and further back there are also 4 sublateral papillae (Figs. 17 and 18). The 6 oral papillae are extremely difficult to see from any aspect, and in only one of these 16 specimens have I been able to view them all in the one individual, and then only under the most favourable conditions, so that one is inclined to doubt the constant presence of the full number. The 4 sublateral papillae are comparatively large and clear. No regular chitinous ring with clefts, as in *O. mansoni*, is present, although the large anterior opening of the pharynx is sometimes partially closed over by a thin indefinite and irregular cuticular membrane.

The nerve-ring is situated 220 to 300 μ from the anterior end of the body (see Fig. 15 n.r.). The excretory pore is situated at 360 to 460 μ from the anterior end (see Fig. 15 e.p.), and near the same transverse plane the small inconspicuous cervical papillae may sometimes be seen. No caudal papillae are present in either sex.

The pharynx (Fig. 17) has a total length of 34 to 50 μ, generally, however, about 45 μ. The anterior portion, which, like that of *O. mansoni*, is shorter and wider and more rounded, is 17 to 30 μ long by 27 to 36 μ wide, the hinder more cylindrical

part being 17 to 27 μ long by 17 to 27 μ wide (except for its posterior end, where it overlaps the oesophagus and reaches a width of 34 μ). Though it is not apparent from the range of sizes just given for the pharynx, the hinder part is slightly longer than the front part in 12 out of the 16 specimens. The well-developed cuticular lining of the pharynx is produced at the junction of its anterior and posterior portions so as to project irregularly forwards (cf. *O. mansoni*, Ransom, 1904, p. 15). Sometimes in *O. parvovum* (cf. Fig. 18) there is also an inward and anteriorly directed projection from the wall of the anterior portion of the pharynx, which does not appear to be represented in *O. mansoni*. The oesophagus has the club-shape comparable to *O. mansoni*, but is shorter than in that species, never reaching over 1.3 mm. in length, and usually being only about 1.13 mm. long.

Male.—9.2 to 14.5 mm. long, by .26 to .33 mm. thick, i.e., rather shorter and thinner than *O. mansoni*. The tail (Fig. 19) is very sharply curved ventrally, much more so than in *O. mansoni*, and ends in a somewhat sharp point, the tip of the tail not being recurved, as in that species. No membranes are present. The cloacal opening is 230 to 300 μ from the tip of the tail, which is distinctly less than in *O. mansoni*. Five pairs of anal papillae are present, 3 preanal arranged in two lines, slightly diverging from back to front, though not as much so as in *O. mansoni*. Two post-anal pairs are found, one close behind the cloacal opening and one a short distance behind that again. I have not been able to distinguish any other papillae similar to those lying one on either side of the cloaca in *O. mansoni*. There are two spicules, one (Fig. 19, l.s.) long and thin, the other (Fig 19, s.s.) short, thick, and boat-shaped in its distal portion, which acts as a guide for the longer spicule. The latter is 3.4 to 4.1 mm. long and 11 to 12.7 μ thick along its length, swelling out to 24 or 30 μ at its open base. The short spicule is 180 to 210 (in one case 240) μ long by a maximum diameter of 27 to 42 μ. These spicules differ in length and thickness from *O. mansoni*.

Female.—13.5 to 20 mm. (generally about 15 mm.) long by .27 to .39 mm. thick, i.e., thinner than *O. mansoni*. The anus (Fig. 20) is 390 μ to 440 (rarely) μ, and vulva .78 to 1.07 mm.

from the tip of the tail, again less than in *O. mansoni*. The uterus and ovary are double, the vagina formed by the union of the two uteri, is about 2.64 mm. long (i.e., more than in *O. mansoni*), but in the middle-third of its length it is generally swollen out into a thinner-walled portion in which 10 or more eggs may lie in one transverse plane (see va., Fig. 20). The posterior end of this swelling is never more than .66 mm. from the vulva, and never more than one egg is found at any point along this terminal portion. This vaginal swelling does not appear to be present in *O. mansoni*. The eggs, too, are smaller than in that species, being 33 to 45 μ long by 25 to 30 μ wide, and often retain their square-ended appearance until ready to be laid. Those in the vagina contain fully-formed embryos (Fig. 21). It will be seen from the above that though this species is closely allied to *O. mansoni*, yet it is a distinct form from the latter. A careful comparison of the two sets of measurements will show that while in some cases the range of extremes overlaps, though it is never the same (e.g., the length of the pharynx, the length of the male and female, position of the anus in the female), yet in other features the differences are distinct, as seen in the presence of the cuticular cephalic wings on the male, the shorter oesophagus, the thinner bodies of both male and female, the more posterior position of the cloacal opening in the male, the fewer anal papillae, the greater length and thickness of the long spicule, and in general less length of the short spicule, the usually more posterior position of the anus and vulva, the longer vagina, and the much smaller eggs.

Dr. Dodd writes as follows:—"'Worm in the eye' in poultry has been known to poultry-keepers in North Queensland for some years. My attention was called to the heavy mortality resulting from this affection early in 1908, but no opportunity for investigating it occurred until late in that year. Then a live fowl was sent from Rockhampton for the purpose of observations in connection with a disease (subsequently ascertained to be Spirochaetosis) which was then causing heavy losses. The bird in question was quite lively, but was affected with marked conjunctivitis, accompanied by slight swelling over the

lachrymo-nasal fossae. Occasionally the bird would scratch its eyes with its claws as if to remove some irritant. On closer inspection one could see one or two worms looking like short pieces of white thread wriggle across the cornea at the lower surface, and by pulling back the membrana nictitans a large number of the worms could be seen in active movement. About 60 of them were removed by means of forceps for subsequent examination. The eyes were then well irrigated with a 5 per cent. warm solution of boracic acid. The treatment was repeated on several occasions. All the worms disappeared and the bird made a complete recovery. Since then opportunity has been taken of examining other birds so affected.

The disease is very common at Cairns, North Queensland, and the loss occasioned there is often serious. It has also been observed at other towns in tropical Queensland, and it will be found probably throughout the coastal towns of tropical Australia. It has not been observed away from the sea coast. This feature was pointed out by Ransom in connection with the occurrence of *Oxyspirura mansoni* in other countries.

The early symptoms of infestation are not very marked, there being slight lachrymation accompanied by slight conjunctivitis. Apparently the presence of the worms, which can generally be found on pulling down the nictitating membrane, causes more or less irritation according to their number; this irritation is frequently shown by the fowl scratching at the affected eye or eyes. If untreated, a purulent conjunctivitis sets in, probably induced by the efforts of the bird to remove the offending bodies, and pus collects at the inner canthi, which may completely close up the eye. The latter becoming very swollen, a sero-purulent material collects in the lachrymo-nasal fossa, the skin over which becomes more or less distended. In bad cases the cornea becomes implicated, and finally loss of the affected eye results. Birds so affected lose flesh considerably, and may die from exhaustion.

The life-history of the worm being unknown, preventive measures cannot be rationally adopted, especially in cases where fowls are allowed large areas in which to run. The treatment usually applied is to remove as many worms as possible by

means of fine dressing forceps, and then well irrigate the eye with warm boracic lotion, but complete success greatly depends on the extent of the complications. A poultry breeder whose fowls suffer considerably states that he has had great success by dropping a few drops of chloroform into the affected eye and then irrigating it with warm water. Very scant attention to this condition is found in English literature, the chief information being given by Ransom (1904), who also summarises previous reports. Neumann just mentions its existence, but classes it under the *intra*-ocular filariae. In all cases observed by me, the worm is *extra*-ocular, as is *Oxyspirura mansoni*."

For convenience of reference I include a table on the following page, which shows the metazoan parasites recorded to date from *Gallus domesticus* in Australia.

METAZOAN PARASITES RECORDED TO DATE FROM *Gallus domesticus* IN AUSTRALIA.

		TREMATODA.	
? (in ovo)	Vic.	Spencer	Proc. Roy. Soc. Victoria, i., 1888, p. 109.
		CESTODA.	
Choanotaenia infundibulum	Vic.	Sweet	Herein.
Davainea cesticillus	N. S. W.	T. H. Johnston	Proc. Linn. Soc. N.S.W., 1909, p. 590.
" "	Vic.	Sweet	Herein.
Davainea tetragona	N. S. W.	T. H. Johnston	Proc. Linn. Soc. N.S.W., 1909, p. 590.
" "	Q'land.	Sweet	Herein.
Davainea varians, n. sp.	Vic.	Sweet	Herein.
Hymenolepis carioca	N. S. W.	T. H. Johnston	Proc. Linn. Soc. N.S.W., 1909, p. 590.
Cysticercus, spp.	N. S. W.	Perrie	Agric. Gaz. N.S.W., iii., 1892, p. 821.
?	"	Perrie	" " " "
		NEMATODA.	
Ascaris, sp.	N. S. W.	Perrie	Agric. Gaz. N.S.W., iii., 1892, p. 821.
[1]*Heterakis compressa*	S. A.	Schneider	Monogr. Nematod., 1866, p. 71.
Heterakis maculosa, aff.	Vic.	Sweet	Herein.
Heterakis papillosa	N. S. W.	Cobb	Agric. Gaz. N.S.W., vii., 1896, p. 748.
" "	"	Johnston	Proc. Linn. Soc. N.S.W., 1909, p. 412.
" "	Vic.	Sweet	Herein.

1 I am indebted to Mr. T. H. Johnston for this reference.

METAZOAN PARASITES (*Continued*).

Heterakis perspicillum (=*inflexa*)	N. S. W.	Cobb	Agric. Gaz. N.S.W., vii., 1896, p. 747, and ix., 1898, p. 316.
” ” (in ovo)	”	Cobb	Agric. Gaz. N.S.W., xvi., 1905, p. 561.
” ”	”	Johnston	Proc. Linn. Soc. N.S.W., 1909, p. 412.
” ”	Vic.; W.A.	Sweet	Herein.
Oxyspirura parvovum, n. sp.	”	Sweet	Herein.
Oxyuris, sp.	N. S. W.	Perrie	Agric. Gaz. N.S.W., iii., 1892, p. 822.
Trichosoma retusum	Vic.	Sweet	Herein.

ARACHNIDA.

Acarus depilis	Vic.; S.A.	Brown	Brit. Med. Jour., 1897, ii., p. 1675.
Argas americanus	W. A.	Theobald	Brit. Mus. (Nat. Hist.), 1904, 2nd Report on Economic Zoology, p. 114.
Argas persicus	N. S. W.	Froggatt	Agric. Gaz. N.S.W., July, 1900 (Misc. Publ.)
” ”	N.S.W.; Vic.	Sweet	Antea, p. 16.
Argas victoriensis	N.S.W.; Vic.	Sweet	Antea, p. 16.
Cyodites nudus, Viz.	N. S. W.	Cleland & Johnston	Proc. Linn. Soc. N.S.W., 1910, p. 28.

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Ransom: B. H., 1905.—U.S. Dept. of Agric., Bureau of Animal Industry, Circ. 85.

Ransom: B. H., 1909.—Smithsonian Institution, U.S. National Museum, Bull. 69.

EXPLANATION OF PLATES.

All figures drawn by aid of camera lucida.

Figs. 1–13.—Davainea varians, sp. n.

Fig. 1 —Head, showing rostellum and suckers with hooks. × about 230.

2a—Rostellar hooks; upper figure in face view, lower figure in side view × almost 1600.

2b—Acetabular hooks. × about 1600.

3-7—Showing variations in configuration of strobila. Nos. 3-6 × about 30, No. 7 × 40.

8—3 segments (apparently 3rd, 4th and 5th), showing alternate genital pores and eversion of cirrus back to last segment. × about 30.

9—Cirrus half everted, showing spines. × 175.

10—Cirrus fully everted. × 175.

11—Two eggs in capsule. × about 380.

12—One single egg. × about 380.

13—Diagram illustrating usual proportionate development of male and female organs in different segments: Testis (t.), cirrus sac (c. s.), cirrus (c.), ovary (o.). vagina (v.), vitelline gland (v. g.), receptaculum seminis (r.), eggs in capsules (e.).

Figs. 14–21.—Oxyspirura parvovum, sp. n.

Fig. 14—Male and female worms. × $1\frac{1}{3}$.

15—Head and anterior part of body of female worms, showing position of pharynx (ph.), nerve-ring (n. r.), excretory pore (e. p.), oesophagus (oes.), intestine (int.), and lateral line (l. l.). × about 60.

16—Outline of head of male, showing oral papillae from ventral surface. × 40.

17—Head of male, showing oral papillae from ventral surface. × about 120.

18—Head, showing structure of pharynx in lateral view. × about 380.

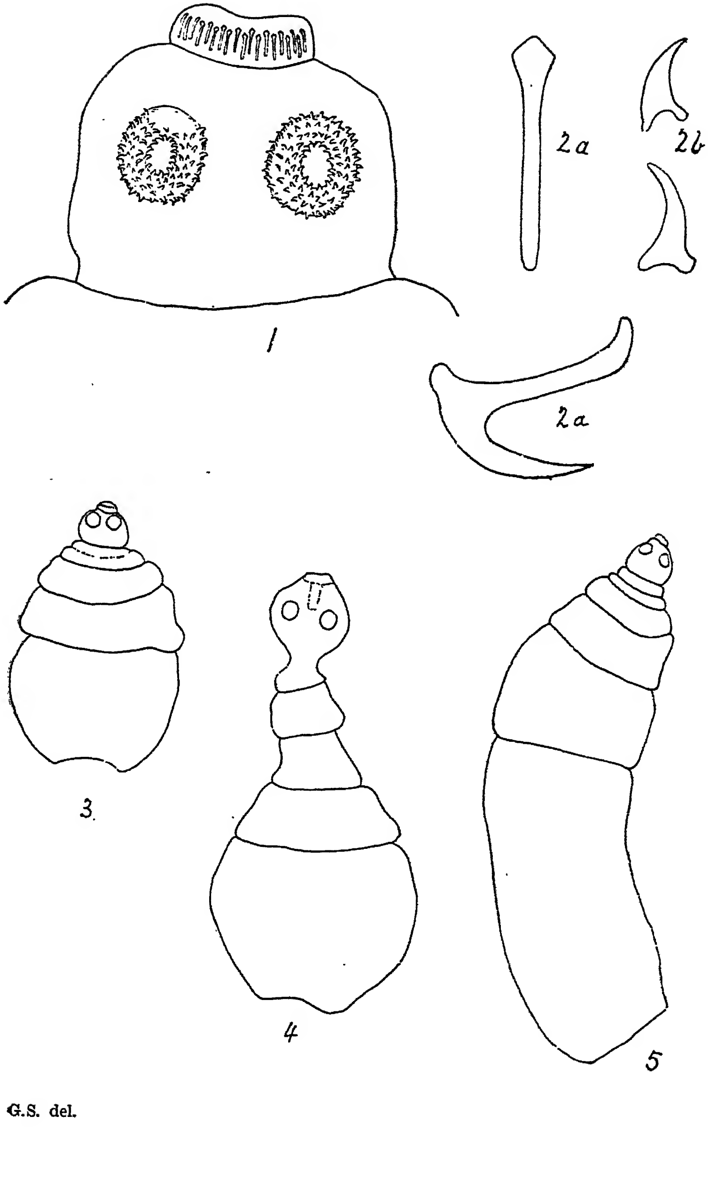
19—Tail of male worm, showing long (l. s.) and short (s. s.) spicules, 5 pairs of anal papillae (a .p.), intestine (int.), ductus ejactulatorius (d. e.), and position of cloacal opening (c. o.). × about 60.

20—Tail of female worm, showing position of vulva (v.), anus (a.), ovary (o.), vagina (va.), and intestine (int.). × 80.

21—Three eggs, showing enclosed embryo. × 220.

END OF VOLUME XXIII., PART I.

[Published August, 1910.]



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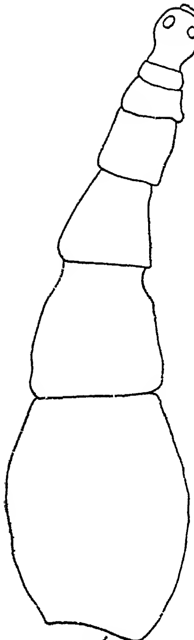

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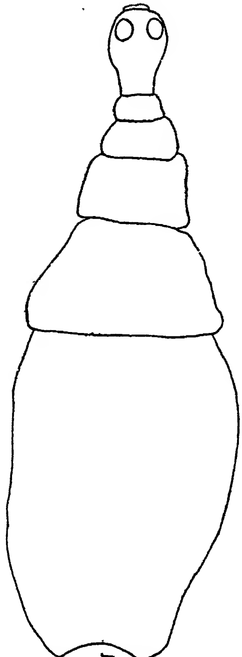

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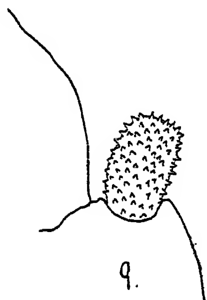

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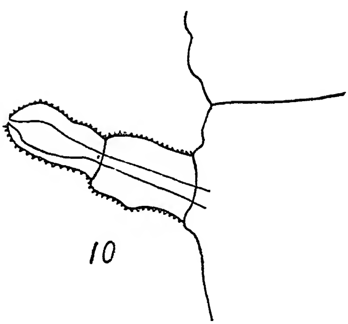

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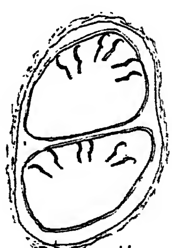

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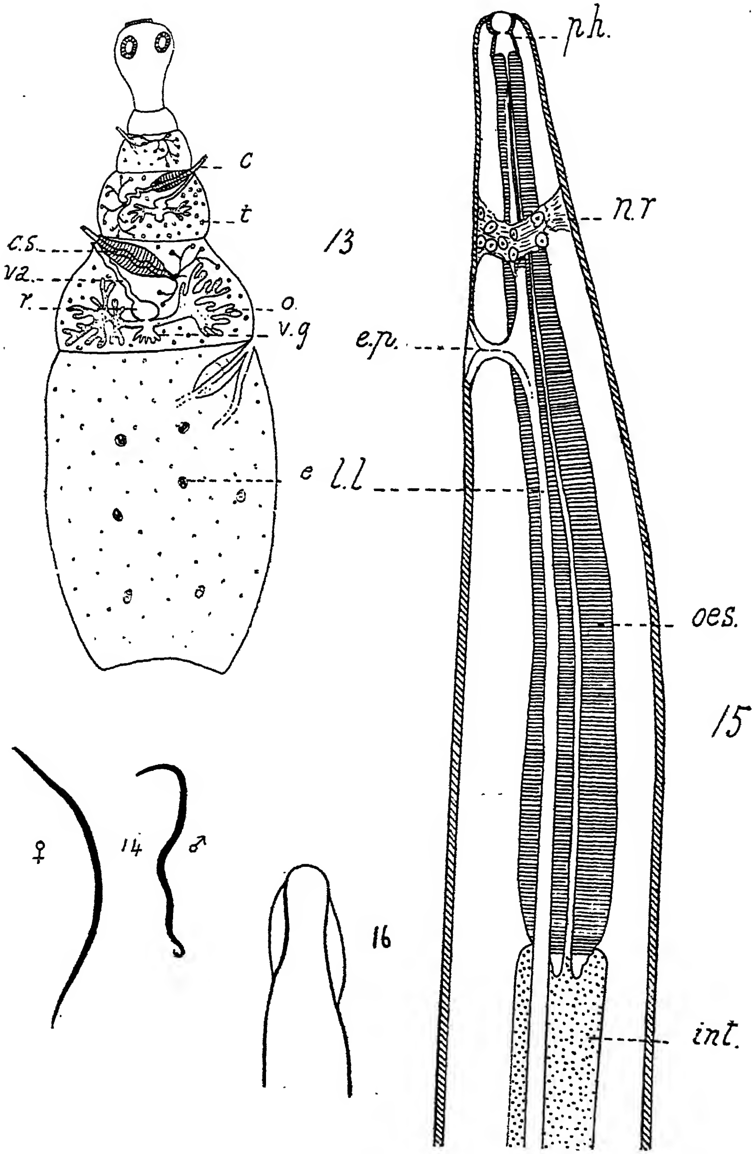

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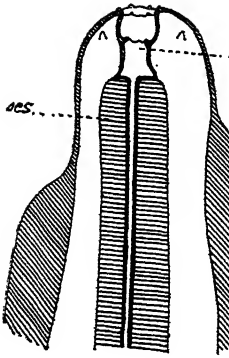

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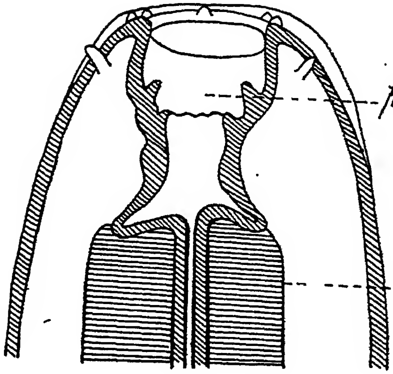

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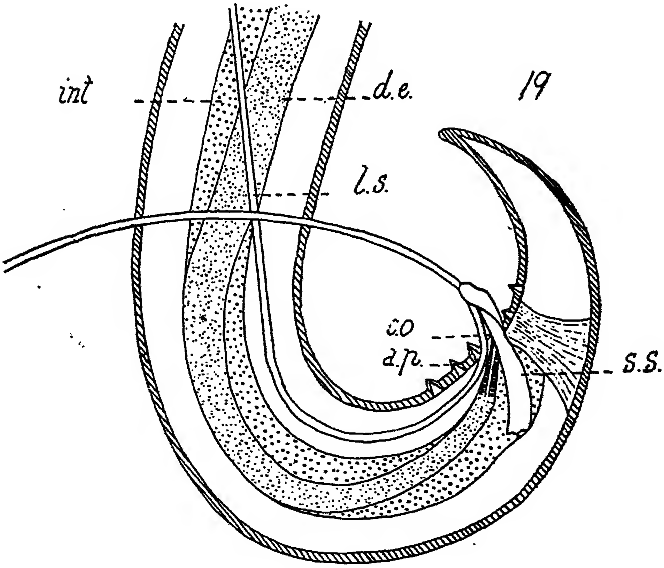

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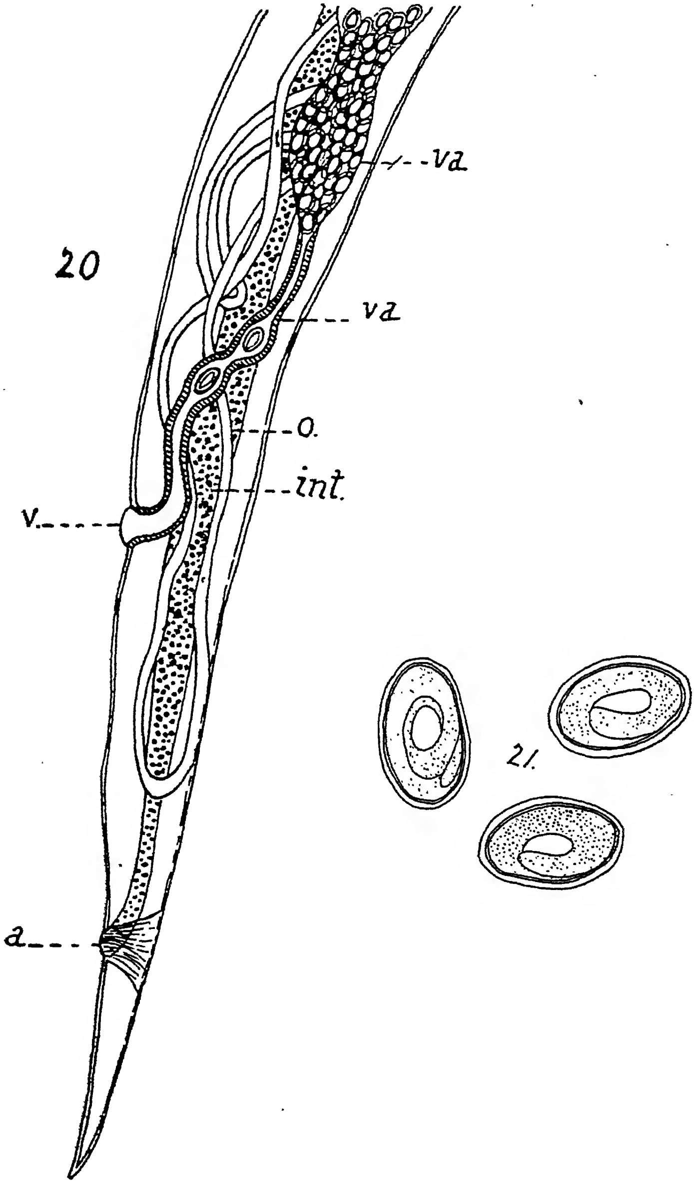

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ERRATUM, p. 257.

Line 10 for "Cape Colony" read "Cape Otway."

[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. II., 1911.]

ART. XXIII.—*On the systematic position of the species of Squalodon and Zeuglodon described from Australia and New Zealand.*

BY T. S. HALL, M.A., D.Sc.

(University of Melbourne).

(With Plate XXXVI.)

[Read 13th October, 1910.]

M'Coy in 1864[1] described *Squalodon wilkinsoni* from the tertiary polyzoal limestone of Cape Colony. The species was founded on a single molar tooth in a good state of preservation. In 1866[2] the species was again characterised on the same tooth, but in less rigid terms, and the essay containing the description was reprinted in the following year[3]. In it M'Coy referred the species to "*Squalodon* or *Phocodon*," the names being synonymous.

In 1875[4] the same author published a description of the same tooth for the fourth time, and gave a good figure. Four years later[5] he figured another tooth of a simpler character, and referred it to the same species as one of the "anterior" teeth. This specimen came from Waurn Ponds, and the same quarry has also yielded a fragment of a molar and an additional probable incisor. These are, it would seem, all correctly referred to the same species.

Still later[6] E. B. Sanger described a similar molar from beds of the same age at Wellington, on the Murray River in South Australia. To this he gave the name *Zeuglodon harwoodi*. I have been unable to trace this specimen, which has apparently disappeared, and Mr. J. J. Fletcher, the secretary of the Linnean Society, is unable to give me any information about it. This

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1 Geol. Mag., v. 4; 1864, p. 145, pl. 8, f. 1.
2 Exhibition Essays, 1866.
3 Annals and Mag. Nat. Hist., v. 20; 1867, p. 191.
4 Prodromus Pal. Victoria; decade 2, 1875, pl. ii., ff. 1-1d.
5 Ib., Dec. 6, 1879, pl. 55, ff. 3-3b.
6 Proc. Linn. Soc. N.S. Wales, v. 5, 1881, pp. 298-300, wdct.

is unfortunate, as the description gave no account of the surface of the tooth, which the figure appears to indicate as smooth. As regards the form of the tooth, it seems to have relatively much more slender roots than M'Coy's type molar, and in the size and arrangement of its cusps it resembles a specimen from Mount Gambier, figured below. I think that this form of tooth must indicate an animal quite distinct from M'Coy's, as such a marked difference in the proportionate size of the roots would probably be correlated with differences in the strength of the jaws.

As regards New Zealand, we find two records of the serrated teeth characteristic of Zeuglodonts and Squalodonts. The first is by Sir James Hector, who in 1881[1] described *Kekenodon onamata*[2] as a Zeuglodont. He had fragments of a lower jaw and of ten imperfect teeth, but figures only the latter. In 1888 J. W. Davis founded *Squalodon serratus* on a tooth partly hidden by matrix. He says that it closely resembles that described by M'Coy as *S. wilkinsoni*, but differs in the number of lateral denticles or cones.

This is, of course, a variable feature depending on the position of the tooth in the series. I would doubtfully put this under the synonymy of Sanger's species, *Z. harwoodi*. Besides these records a Squalodont tooth was found some years ago at Table Cape by Prof. Baldwin Spencer, and was handed over to Prof. Ralph Tate at the time. The specimen is in the Adelaide University Museum, and I have to thank Mr. W. Howchin for an opportunity of examining it. It bears a label with a *MS* name of the late Professor Tate's, namely, *Zeuglodon brevicuspidatus*. In the same drawer was found a paper with the following note in Tate's handwriting:—"*Zeuglodon s.*, distinguished from *Z. Harwoodi* and *Z.* [blank] (Alabama) by its small cusps and deep angular rugosities, also from *Squalodon Wilkinsoni* by the same characters apart from its prob. diff. generic location."

As Mr Howchin tells me, it is not known whether the above description was intended to apply to the present specimen. The probabilities are, I think, that it was so.

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1 Trans. and Proc. N. Zealand Inst., v. 13, 1881, p. 435, pl. 18.

2 Zittel in his Handbook misspells both the generic and specific name, and gives a puzzling variant of *S. wilkinsoni*. The errors are repeated in the French edition.

The specimen consists of merely partly hollow crown packed with the characteristic large, well-rounded quartz grains of the basal beds at Table Cape. A reference to the figure will show the obliquity of the crown and the presence of two large cusps on the front edge, and three on the hind one. This points in the direction of the Squalodonts rather than of the Zeuglodonts. The crown is higher and narrower than M'Coy's type, and thus approaches the more anterior tooth figured from Spring Creek. Though the root is absent I am of opinion that the Table Cape specimen is conspecific with M'Coy's species, and is more anterior than his type.

The Victorian National Museum has a fine molar from the Mount Gambier polyzoal limestone, which has been referred to above.

I have what appears to be a premolar from the Middle Spring Creek beds, which I found several years ago. These are all the records or material of which I can find trace. No other bones belonging to these whales have been found unless some of those recorded as "Cetotolites" may be so referred.

Hector's *Kekenodon* in some ways stands apart from all the others. The crowns of the teeth as compared with the roots are much smaller. The surfaces of the crowns are stated by Hector to be fluted and polished. Casts of some of the teeth are in the National Museum here, but the flutings are not shown, and cannot, I think, have been as pronounced as in *S. wilkinsoni*.

We have then three species, which, as I shall attempt to show, it would seem advisable to refer to as many distinct genera.

The separation of the Zeuglodontidae and the Squalodontidae rests fundamentally on the formation of the skull, the Zeuglodonts being more generalised, or archaic, in that the anterior nares are far forward, the nasals being large. Both families are usually grouped with the Cetacea, the latter as a distinct sub-order, Archaeoceti or Zeuglodontes. The Squalodonts with small nasal bones, and an anterior nasal opening on the top of the head, are grouped with the Odontoceti under the family Squalodontidae.

The only suggested difference shown by the teeth in the two families is, as has been pointed out by several observers, that

the cusps on the anterior cutting-edges in Squalodonts are less conspicuous than those on the hind edges[1].

There seems to be great variation in the ornament on the teeth, though perhaps imperfect figures and descriptions may mislead us here, as very few authors pay much attention to the point.

Andrews[2] says that in *Prozeuglodon* the enamel at the base of the crown is raised into fine ridges. In *Z. isis* he describes the surface, especially that of the inner side of the crown, as covered with anastomosing ridges, which do not run on to the serrations of the posterior border. Carus[3] appears to figure the teeth of *Z. hydrarchos* as smooth. Gaudry[4] figures *S. grateloupei* as roughly ridged, but his illustration is only a woodcut. *Zeuglodon cetoides* he figures as quite smooth, but the drawing is, he says, from a cast. Koch[5] shows *Z. macrospondylus* from Alamaba as fluted. Lydekker[6] shows the teeth of Z. *caucasicus* (type of *Microzeuglodon*, von Stromer) as smooth, *Rhizoprion bariense*, Jourdan's figures[7] show with a few coarse longitudinal grooves. Owen[8] shows the teeth of *Z. cetoidės* as smooth. Casts of the teeth of *Z. cetoides* in the National Museum show the molars and canines to be smooth and polished. Van Beneden's "Description des ossements fossiles des environs d'Anvers" and the "Ostéographie des cetacés" by Gervais and van Beneden are unfortunately not in Melbourne, but the latter author[9] in speaking of *S. antverpiensis* says the crowns of the teeth are coated with enamel covered with grooves separated from one another by an equal space of 1 mm. and his figure (pl. 1) shows a tooth ornamented like M'Coy's type of *S. wilkinsoni*. He gives further particulars as to the surface of the teeth which show their resemblance to M'Coy's species and points out that the teeth of *Zeuglodon* are all remarkable by the number and

1 e.g., Lydekker, 1893, p. 9.
2 Andrews, 1906, p. 255.
3 Carus, pls. 39A, 39B.
4 pp. 30 and 38.
5 Koch, pl. 7.
6 Lydekker, 1892.
7 Jourdan, pl. 16.
8 Owen, pl. 7.
9 Van Beneden, 1876, p. 476.

form of the crenulations and the two edges always resemble one another more than in Squalodons. The same author in another paper[1] says that in *S. servatum* the teeth are coated with a thick layer of enamel the surface of which is always "striée ou guillochée." For the latter word I can get no satisfactory meaning. "Engine-turning" or the geometric interlacing of curved lines does not seem applicable to any ornament described or figured elsewhere.

Similar references could be multiplied but the quotations are sufficient to show that ornament alone is not sufficient to fix the generic position of an unknown tooth.

An additional character common to the Northern Zeuglodonts and Squalodonts is the complete separation of the divergent roots of the molar teeth. This character is not shown in any of the corresponding teeth in the Southern forms as far as is known. In *Prosqualodon* from the Chubut deposits of Argentina Lydekker[1] states that in the molariform teeth the fangs have coalesced, but are separated by a deep groove, and he gives a text-figure showing this feature. True[2] says the teeth of *Prosqualodon* which he examined did not exhibit the amount of divergence that Lydekker figured. Sanger[3] says that the two fangs of his species are connected by an isthmus. The same character of the coalescence of the fangs is shown in M'Coy's type, in the specimens from Mount Gambier and from Spring Creek.

The fusion of the roots seems to be of sufficient importance to separate the Southern forms from *Squalodon* and *Zeuglodon* alike, and as Lydekker's *Prosqualodon* shows the fusion and is undoubtedly Squalodont it will be found advisable, I think, to refer the Australian species to the same family of short-beaked forms.

In the case of *Kekenodon* there is a peculiarity. The roots are united in most of the teeth, but in some at least they run parallel, but not quite in contact. Their passage towards complete union has not advanced as far as in the Australian species. One tooth, moreover, has a third root, a feature which is more ar-

1 Lydekker, 1899, p. 921.
2 True, 1910, p. 450.
3 Sanger, 1881, p. 298.

chaic than anything found in *Squalodon*, but occurs in the Fayum *Prozeuglodon*.[1] This character is regarded by Andrews as of generic value.

The differences which exist in the teeth are, I think, of sufficient importance to enable us to separate three genera which may be referred to the Squalodontidae and may be defined as follows:—

KEKENODON, Hector.

Teeth with massive roots, three or four times as long as the crown. Roots usually united for their whole length, and in every case never widely separated. A third root in some teeth. Lateral cusps on the crowns strong and freely projecting. Surface of crowns, according to Hector, fluted.

Only species *Kekenodon onamata*, Hector.

PARASQUALODON, gen. nov.

Roots of molariform teeth slightly more than twice the length of the crown. Roots united throughout their length and in some teeth slightly hooked at the end. Lateral cusps on the teeth rather small. Surface of crown covered with cord like the tip of the tooth. Ridges roughened with small rounded prominences. In the (?) premolar figured (Pl. XXXVI., Fig. 3) the sharp edges of the teeth are slightly serrated, the serrations varying in size from these prominences to distinct, though small, cusps. Anterior teeth with the same cordlike ornament, but without lateral cusps, and from the same horizon, are provisionally referred to the same genus and species.

Only species *Parasqualodon wilkinsoni*, M'Coy.

Metasqualodon, n. g.

Roots of molariform teeth slender and only a little longer than the height of the crown, the two fangs connected by a thin "isthmus" much as figured by Lydekker in *Prosqualodon*, but the fangs more nearly approaching one another. The material does not inform us as to whether the fangs were connected

1 Andrews, p. 251.

throughout their length by the isthumus, or whether they projected freely beyond it. Lateral cusps rather large. Ornament as in Parasqualodon.

Only species *Metasqualodon harwoodi*, Sanger.

In discussing the affinities of *Prosqualodon*, Lydekker says that in the structure of the nasals the South American genus is more generalised than *Squalodon*, while in the character of the teeth it is more specialised. As we know only the teeth of our Australasian genera, and these imperfectly, we cannot say whether or not they were in advance of the specialisation of the skull.

Geologists are as yet undecided as to the age of the Patagonian tertiaries. Those in the United States, and most of those in Europe, refer to the Santa Cruz beds which yielded *Prosqualodon* to early miocene or perhaps oligocene. Von Ihering, who has spent many years on the task, and is familiar with the recent mollusca of South America, still fights vigorously for their eocene age, and is, I think, working on correct lines.

The New Zealand *Kekenodon* is said by Hector to be eocene, but the matter is still in doubt. As regards the beds in Southern Australia which have yielded Squalodonts, opinions vary between eocene, oligocene and miocene. At present those which have yilded *Prosqualodon* are spoken of merely as Janjukian. The polyzoal limestone of Mount Gambier is, of course, practically devoid of mollusca, and its relationships are consequently not easy to settle, but they appear to lie rather with Muddy Creek, which is Balcombian, than with Janjukian. The beds of the Murray River cliffs, whence Sanger's type came, are generally regarded as Janjukian, but variations may occur in such a great range of outcrop.

There are differences of opinion as to the sequence of these two subdivisions of the Barwonian system, my view being that Janjukian is the older.

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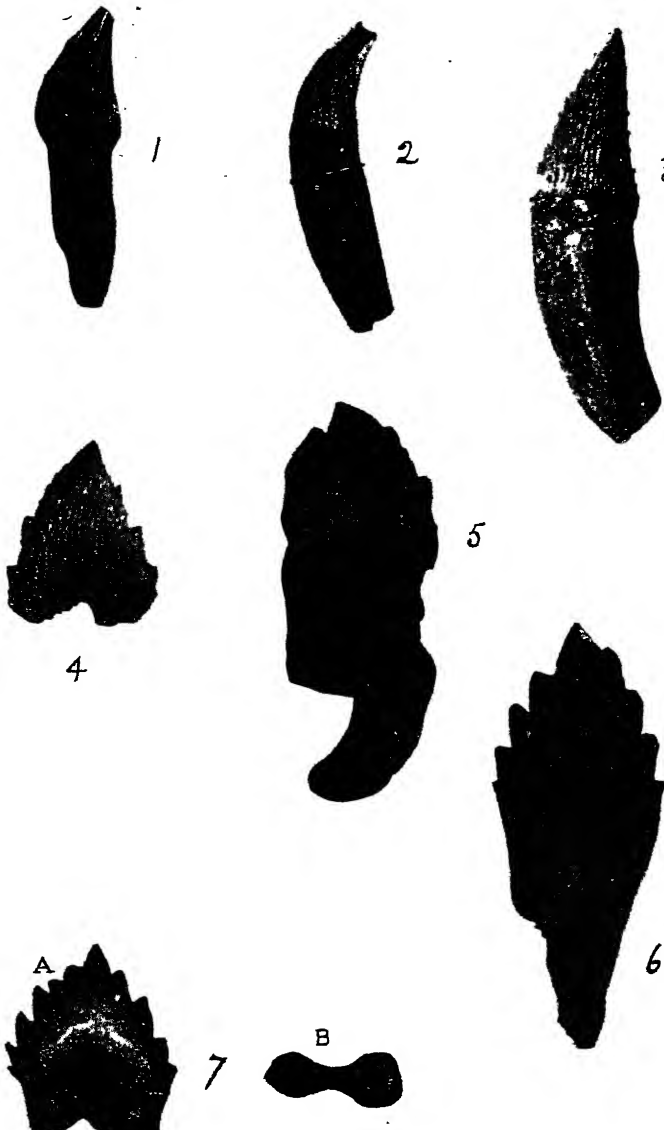
Note.—Ostéographie des Cétacés vivantes et fossiles, by van Beneden and Gervais, and the former author's Description des ossements fossiles des environs d'Anvers, in Ann. Mus. H.N. Belgique are not available in Melbourne.

DESCRIPTION OF PLATE XXXVI.

Fig. 1.—Incisor of (?) *Parasqualodon wilkinsoni*, Waurn Ponds. (Coll. Nat. Mus.).


1
2
3
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A
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B

Fig. 2.—Incisor of *P. wilkinsoni*, Waurn Ponds. (Coll. Nat. Mus.). Figured by M'Coy.

3.—Premolar of *P. wilkinsoni*, Spring Creek. (Coll. T. S. Hall).

4.—Molar of *P. wilkinsoni*, Table Cape. (Coll. Geolog. Dept. Adelaide Univ.).

5.—Molar of *P. wilkinsoni*, Castle Cove, Cape Otway. (Coll. Nat. Mus.). M'Coy's type.

6.—Molar of *Metasqualodon harwoodi*, Mount Gambier. (Coll. Nat. Mus.).

7.—(A) Molar of *M. harwoodi*. After Sanger.

(B) Transverse section of roots of molar of *M. harwoodi*, showing their union. After Sanger.

(The figures are all about natural size).

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. II., 1911].

Art XXIV.—*Further Descriptions of the Tertiary Polyzoa of Victoria.*

Part XI.

By C. M. MAPLESTONE.

(With Plates XXXVII.-XLVIII.).

[Read 13th October, 1910.]

Catenicella bairnsdalei, n. sp. (Pl. XXXVII., Fig. 1).

Zooecium oval, broad, compact; with eleven narrow fenestrae. Thyrostome arched above, straight below; distal margin raised. Two long, deep, uncalcified areas situate laterally: the distal angles produced into acute processes, probably avicularian.

Locality.—Mitchell River (J. Dennant).

A single specimen. This is a very solid looking form; the proximal fenestrae are well defined, the distal ones less so and the interspaces there have the appearance of transverse ribs stretching across the frontal wall. The uncalcified lateral areas are surrounded with raised, smooth walls; those on the right hand side are merged into one long area.

Catenicella ampla, Waters. (Pl. XXXVII., Fig. 2).

I have included an illustration of a zooecium of this species as the specimen is much more perfect than any figured in Dr. MacGillivray's Monograph.

Catenicella cuneiformis, n. sp. (Pl. XXXVII., Fig. 3).

Zooecium cuneate, ventricose, narrow; with eleven fenestrae. Thyrostome very large, arched above; lateral and distal margins raised; a very small sinus in the proximal margin. An acute spinous process at each distal angle with an avicularium below.

Locality.—Clifton Bank, Muddy Creek (Dr. Hall).

The very large thyrostome with raised margin, the narrow fenestrae and the angular spinous processes separate this from other species.

Catenicella morningtoniensis, n. sp.

(Pl. XXXVII., Fig. 4).

Zooecium oval, elongate, with wide lateral processes and nine to fifteen very narrow fenestrae. Thyrostome arched above, straight below, with a longitudinal ridge above it. Two to three elongated depressed uncalcified areas in the lateral processes and one on each side above the thyrostome; a spinous process on the outer angles.

Locality. Balcombe Bay, Mornington (Dr. Hall).

This is near *C. marginata*, Waters, but the number of the fenestrae is much greater, they are narrower than in that species, and the uncalcified areas on the margin are more numerous.

Catenicella concinna, n. sp. (Pl. XXXVII., Fig. 5).

Zooecium cuneate, ventricose, smooth; with nine fenestrae, very slightly depressed. Thyrostome arched above; lower margin incurved in the centre; a broad ridge above. Lateral processes are either absent or aborted. Avicularia (?) at distal angles.

Locality.—Mornington (Dr. Hall).

This is a very distinct species. It is exceedingly ventricose, with a smooth, shining surface, and there are apparently no lateral processes. The distal angles are not quite perfect, but present indications of having borne avicularia.

Catenicella elegantissima, n. sp. (Pl. XXXVIII., Fig. 6).

Ooecium ovoid, smooth; surmounted by a flattened umbonate process, below which the surface is slightly depressed over about a third of the ooecium; in the depression there is near the proximal margin a curved row of about 20 small pores, above which is a similarly curved row of 5 or 6 larger pores. Ooecial opening broad; proximal margin slightly incurved; a broad sinus in the distal margin. Five narrow fenestrae and a small depressed uncalcified area on each side, below the ooecial opening. Zooecia unknown.

Locality.—Spring Creek (Dr. Hall).

This is a very elegant form, its great peculiarity is the depressed area on the distal part, perforated with two rows of pores. This part was probably covered with an epitheca when living. The sinus in the distal margin of the ooecial opening is peculiar to this species.

Catenicella minutissima, n. sq. (Pl. XXXVII., Fig. 7).

Ooecium pyriform, with a slightly depressed falciform granular area on each side. Nine very narrow fenestrae below the ooecial opening. Ooecial opening very wide; proximal margin extended upwards in the median part causing the opening to be narrow and curved downwards at the ends: an irregularly shaped lateral process on each side. Zooecia unknown.

Locality.—Campbell's Point (J. F. Mulder).

This is an extremely small ooecium; I know of no species of *Catenicella* that has zooecia so minute as would correspond with the dimensions of this ooecium. The lateral processes shown are probably part of the matrix of the formation and not really a part of the ooecium.

Catenicella longispinosa, n. sp. (Pl. XXXVII., Fig. 8).

Zooecium oval, ventricose; with wide lateral processes and seven large fenestrae. Thyrostome arched and raised above, with a very small sinus in the proximal margin. Two deep depressed uncalcified areas on each side. A long acute bilaminate spine on the distal angles.

Locality.—Campbell's Point. (J. F. Mulder).

This is a large species and is distinguished by the very long distal bilaminate spines which clearly show the manner of their formation as the sides do not completely join, but leave, in the left-hand one, a long narrow cavity and in the other a triangular hollow: the spine on the extreme right hand has not developed completely and may possibly indicate the presence of an avicularium in lieu of an elongated spine.

Strophipora triangularis, n. sp.
(Pl. XXXVIII., Figs. 9 and 9a).

Ooecium ovoid, with two rounded ridges descending from near the summit downwards and outwards, terminating on a

level with the proximal margin of the ooecial opening on each side, leaving a depressed triangular area between; a large slightly depressed pyriform area on each side beyond the ridges. Ooecial opening large, transversely elliptical: a single rounded foramen below it on a slightly elevated umbo on the median line. Dorsal surface smooth, with two very slightly raised narrow ridges descending from the apex with a hastate depressed area between; at the proximal end of which there is a subtriangular area very slightly calcified and almost transparent. Around the sides and crossing over near the apex is a narrow ridge, probably the dorsal margin of the depressed areas seen on the front view. Zooecia unknown.

Locality.—Campbell's Point (J. F. Mulder).

The slide upon which these two specimens are, was given to me by Mr. Mulder, and I consider them as exhibiting the frontal and dorsal aspect of the one species, though not having exactly the same outline; the difference is not more than can be seen in the ooecia of other species of Catenicellidae, and as the dorsal surface has a somewhat depressed triangular area similar to that on the frontal surface I do not think there can be any doubt about it. The small round foramen on the raised umbo is analagous to that occurring on the frontal ridge of the zooecia of the other species of *Strophipora*.

Strophipora laevis, n. sp. (Pl. XXXVIII., Fig. 10).

Zooecium ovate, smooth. Thyrostome large, suborbicular; proximal margin with a broad, flat, protruding denticle. The central portion of the zooecium bears a slightly raised ridge extending from the thyrostome to near the proximal part, with a pore below the thyrostome. A curved spinous process on each side extending to the distal end of the zooecium.

Locality.—Mornington (Dr. Hall).

A single specimen. The zooecium is very smooth and the ridge in the centre is very slightly raised, but its presence and that of the pore show it to be a *Strophipora* though these characteristics are less marked than in the other species. The curved spinous processes arching over the distal part are peculiar to this species.

Claviporella bicornis, n. sp. (Pl. XXXVIII., Fig. 11).

Ooecium elongated, irregularly oval. Ooecial opening large, curved distally; proximal margin denticulate. On each side of the ooecial opening there is a large, thick, spinous process, the left one straight, the right-hand one curved. Below the ooecial opening on each side is a short cylindrical adnate process, with a truncated end, the right-hand one the longer. Zooecia unknown.

Locality.—Campbell's Point. (J. F. Mulder.)

This is a very peculiar form owing to the presence of the large spinous process on each side of the ooecial opening, similar, but much larger in proportion, to those on the ooecia of *Cl. aurita* and *Cl. geminata* (recent species). The short truncate processes below the ooecial opening are peculiar to it, they are possibly avicularian. The denticulation on the proximal margin of the ooecial opening may possibly be caused by the fracture of the frontal wall of the ooecium, but the inner edges of the denticles have 2.3 acute points, whereas if it had been caused by fracture the edges would most probably have been straight, or nearly so. The irregular flat curved process on the distal end may be a portion of the matrix of the deposit, and not actually belonging to the specimen.

Claviporella airensis, n. sp. (Pl. XXXVIII., Fig. 12.

Zooecia irregularly cuneate; below the thyrostome is a small elongated, vertical slit or pore. Thyrostome arched above; a deep rounded sinus in the proximal margin. Ooecium globose, smooth, with faint lines radiating from the ooecial opening, which is of the same shape as the thyrostomes, but larger, and loftier in proportion.

Locality.—Aire coastal beds (Dr. Hall).

A single internode composed of three zooecia, and an ooecium; the zooecium proximal to the ooecium is apparently double as there are two pores on the raised front wall, but, as there is no thyrostome to either portion, it probably represents two imperfectly developed zooecia. This is near *Cl. longicollis* McG., but in this species there is only a small slit in the place of the larger depressed banded area in that species.

Vittaticella cruciformis, n. sp. (Pl. XXXVIII., Fig. 13).

Zooecia cuneate, elongate, ventricose. Thyrostome arched above, straight below. Large, broad lateral vittae with 4 to 6 large circular fenestrae (?).

Locality.—Bairnsdale (J. Dennant).

A portion of the specimen is partially obscured by matrix. It is cruciform in shape and is composed of 3 (possibly 4) zooecia, and in the centre there is a rounded elevation which may be an ooecium. It is distinguished from all other Vittaticellae by the very broad vittae with a few, comparatively large, fenestrae (?) covered with an ectocyst in lieu of the small pores usually present in the vittae of the other species.

Brettia brevis, n. sp. (Pl. XXXVIII., Fig. 14).

Zooecia cuneiform, subtubular, ventricose. Thyrostrome orbicular, surrounded by a wide peristome, the margin of which bears very short blunt spinous processes.

Locality.—Spring Creek (Dr. Hall).

This is a very interesting form which I assign to *Brettia*, though it is very much shorter in proportion to its width than any of the recent species, and it is much more highly calcified than they are. The genus has not hitherto been recorded as fossil.

Caberea morningtoniensis, n. sp.

(Pl. XXXIX., Fig. 15).

Zoarium ligulate. Zooecia multiserial. Aperture large, oval, elongate; margins raised, very broad and granulated; a spine at each distal angle; numerous small oval avicularia scattered irregularly on the surface of the zoarium. A very large pedunculate avicularium on one side of the aperture. Ooecia mitriform.

Locality.—Balcombe Bay, Mornington (Dr. Hall).

This is near *C. grandis*, Hincks., but differs from it in the very broad granulated margins of the aperture, in the absence of any scutum and in the presence of the very large pedunculate avicularia on the side of the aperture; these are, most of

them, broken off, leaving a portion of the tubular stem exposed, but one on the left-hand side is preserved. The basal wall of an ooecium is seen above the distal end of the aperture of uppermost median zooecium. The specimen is not in very good condition, portions of it being obscured by sandy particles, but there is no doubt as to its specific distinction.

Farcimia airensis, n. sp. (Pl. XL., Fig. 16).

Zoarium erect, free. Zooecia long and narrow, with raised margins. Aperture elongated, oval; sides straight; ends curved, proximal end narrower than the distal one; margins raised. Numerous large spatulate avicularia on one side of the zoarium.

Locality.—Aire River, Cape Otway (Dr. Hall).

This is near *F. lusoria*, Waters, but the zooecia are longer and narrower, and the large spatulate avicularia are peculiar to it.

Menipea uniserialis, n. sp. (Pl. XL., Fig. 17).

Zoarium erect; the zooecia in single series. Zooecia oval with large elliptical aperture, which at the distal end bears, below the level of the margin, a median broad process leaving a narrow space on each side; the inner lateral and proximal margins of aperture granulated; a very small spine on one side of the margin near the distal end; a very large sessile avicularium on the other side of the zooecia.

Locality.—Aire coastal beds (Dr. Hall).

This species I assign to *Menipea*, though the zooecia are in single series, instead of the usual bi- or multiserial series, as it has a large sessile avicularium on one side of the zooecia.

Synaptacellidae, nov. fam.

Zoaria free, rigid. Zooecia in single series.

The zoarial character of the species I have placed in this family is quite distinct from that of the other families in which the zooecia are in single series. In Catenicellidae the zooecia are joined together by flexible chitinous tubes. In Eucratiidae they are only sometimes uniserial, and are subcalcareous, not rigidly connected.

In neither of these families could they be included. I am aware that it is not considered advisable to institute a new family, or even a new genus, upon purely zoarial characters, especially as, at the present time, the structure of the operculum, and whether the rosette plates have a single pore, or many, are considered by some to be of equal, if not greater, taxonomic value than the more evident zooecial characteristics, and that zoarial form is almost entirely ignored; but the species here described, six in number, are so very distinctive in their zoarial character that I consider the creation of a new family for their reception is quite justified.

SYNAPTACELLA, nov. gen.

Character as for family.

Zooecia ovoid, pyriform or cuneate. Aperture large, oval; margins raised.

The zooecial characteristics of the species of this genus vary somewhat, but they all resemble one another to such an extent that, taking into consideration their uniform zoarial character, I consider they may properly be placed in the one genus.

Synaptacella asymmetrica, n. sp. (Pl. XL., Fig. 19).

Zoarium free. Zooecia in single series. Zooecia ovoid and cuneiform; aperture oval or suborbicular, small and asymmetrical; margins thick and raised; a large round depressed area in the proximal part of the basal wall, and a small one in the distal end; an avicularium at the distal part of the zooecia on the side towards which the aperture is directed.

Locality.—Spring Creek (Dr. Hall).

The specimen consists of two zooecia only, the proximal one not quite perfect, and the distal one has a rounded ridge on one side. The comparatively small asymmetrical aperture with the very thick raised margin and the small lateral avicularia are distinctive.

Synaptacella gibbosa, n. sp. Pl. XL., Fig. 20).

Zoarium free. Zooecia in single series. Zooecia irregularly cuneiform, asymmetrical; aperture elongated, subtriangular, rounded

distally; margins raised, broad, with a narrow inner rim; a small spine on each side near the distal end; an ovoid avicularium below.

Locality.—Griffin's, Moorabool (Dr. Hall).

The specimen consists of two zooecia only. Its chief peculiarity is the asymmetrical form of the zooecia, one side is slightly curved inwardly, the other side projects laterally, forming an obtuse angle. The bases of the marginal spines are preserved on the proximal zooecium only and on that one the avicularium is broken off.

Synaptacella crassimarginata, n. sp. (Pl. XL., Fig. 21).

Zoarium free, branching. Zooecia in single series, ovoid, contracted proximally; aperture oval, with very wide, raised margins; a large rounded depressed area in the proximal part of the basal wall, and two small narrow ones distally; a raised ovoid avicularium below.

Locality.—Griffin's, Moorabool (Dr. Hall).

This specimen consists of three zooecia, the two distal ones branching from the proximal one.

Synaptacella ovalis, n. sp. (Pl. XL., Fig. 18).

Zoarium free. Zooecia in single series; ovoid: aperture oval, with a raised double margin; an avicularium at each distal angle, and sometimes one on an umbo below the aperture; a spine (?) above the centre of the distal edge of the aperture.

Locality.—Griffin's, Moorabool (Dr. Hall).

This also is a small fragment, consisting of two zooecia only. The aperture is a very regular oval; the avicularia on the distal angles are indicated by short tubular processes, which may be the bases of pedunculate avicularia, and the process on the distal edge of the aperture of the upper zoarium may represent either the base of a spine or a small avicularium.

Synaptacella dennanti, n. sp. (Pl. XLI., Fig. 22).

Zoarium free. Zooecia in single series; ovoid, elongate, contracted proximally; aperture oval, occupying nearly two-thirds

of the length of the zooecia; margins raised; a small circular avicularium below the aperture.

Locality.—Mitchell River (J. Dennant).

A single specimen, consisting of two zooecia only. The avicularium on the distal zooecium is broken away, showing the form of the avicularian chamber.

Synaptacella recta, n. sp. (Pl. XLI., Fig. 23).

Zoarium free, erect. Zooecia in single series, pyriform; aperture ovoid; margins raised. Small oval avicularia on a slightly raised umbo below the aperture.

Locality.—Griffin's, Moorabool (Dr. Hall).

The specimen consists of two zooecia only; it is not in very good preservation, as there is a longitudinal fracture running through the lower zoöecium, and the margins of the aperture are not quite perfect, but it is quite distinct from the other species.

Cellularia balcomiensis, n. sp. (Pl. XLI., Fig. 24).

Zoarium free. Zoöecia biserial, ovoid, contracted proximally; aperture oval, elongated; margins raised and thickened; a large round, depressed area in the proximal part of the basal wall, with two smaller ones distally. No avicularia.

Locality.—Balcombe Bay, Mornington (Dr. Hall).

This is a very small form, and though not in good preservation, is quite distinct from *C. triangulata*, Mapl., the only other species hitherto recorded from our Tertiary formations. The two specimens figured differ somewhat, one being in the distal part almost in single series, but I consider they are the same species.

Cellularia mooraboolensis, n. sp. (Pl. XLI., Fig. 25).

Zoarium free. Zooecia biserial, directed alternately outwards, elongated, with oval aperture; margins raised and wide, with a narrow inner rim; a spine on each side near the distal end; a circular raised avicularium below the aperture.

Locality.—Griffin's, Moorabool (Dr. Hall).

A single specimen, consisting of five zooecia; it differs from *C. balcomiensis* in the distal part of the zooecia, being directed alternately outwards, and in the presence of avicularia.

Membranipora laevissima, n. sp. (Pl. XLI., Fig. 26).

Zoarium encrusting. Zooecia undefined, slightly calcified, very shallow; aperture oval, with smooth margins; interspaces only slightly raised, smooth, with small oval avicularia between the zooecia.

Locality.—Wilkinson's No. 4 (Dr. Hall).

A single specimen growing on a fragment of a bivalve shell. It is very flat and thin looking, more like a thin gelatinous film than a calcified structure, the surface of the shell is exposed in the apertures, and there is no trace of any basal wall, which was probably membranous.

Membranipora ovifera, n. sp. (Pl. XLII., Fig. 27).

Zoarium encrusting. Zooecia irregularly oval, in transverse rows; aperture large; margins raised, flat; scattered vicarious oviform avicularia, with oval mandibular area.

Locality.—Orphanage Hill, Geelong (Dr. Hall).

This in appearance resembles some specimens of *M. gregsoni*, McG., but the form of the avicularia is very different; all, except one, of the apertures are filled with fine particles of sand, and it is interesting to note that one of the zooecia is regenerated, the margin of the later formed one showing within that of the older.

Steganoporella dennanti, n. sp. (Pl. XLIII., Fig. 28).

Zoarium in vincularian form. Zooecia dimorphic, elongated, arched and overlapping distally. Cryptocyst depressed, occupying about half the length of the zooecia, perforated with very small pores; a rounded opesiule on each side at the distal end; median process straight; oral shelf forming a subtriangular or cordate arch. In the " B " zooecia the polypide tube descends distally to the basal floor.

" A " zooecia 1.2 mm. long, 0.4 to 0.6 mm. wide.

" B " zooecia 1.3 mm. long, 0.7 to 0.8 mm. wide.

Locality.—Mitchell River (J. Dennant).

The frontal edges of the lateral and distal walls of the zooecia are apparently eroded, and are of a dark colour, probably the animal tissue of the polypide mineralised. The lateral and oral shelves are minutely granulated, not perforated. In the "A" zooecia the cryptocyst and the median process only are seen, the polypide tube being either hidden or broken away, but in the lower "B" zooecium, of which only the distal portion is preserved, the polypide tube is present, it descends towards the base, and is produced distally a considerable distance.

Steganoporella bairnsdalei. (Pl. XLIII., Fig. 28a).

Zoarium in vincularian form. Zooecia dimorphic, elongated; arched and overlapping distally. Cryptocyst depressed distally, occupying about two-thirds of the length of the zooecia; coarsely perforated. Oral arch incurved at the proximal ends. Oral shelf forming a subtriangular arch in the "B" zooecia. Polypide tube showing only as an opening near the distal margin of the cryptocyst.

"A" zooecia 1 to 1.2 mm. long, 0.4 mm. wide.

"B" zooecia 1.6 mm. long, 0.6 mm. wide.

Locality.—Mitchell River (J. Dennant).

The zooecia are smaller and narrower in proportion than those in the preceding species; the oral arch is incurved at the proximal ends, showing the condyles. The details are not well preserved, only the upper part of the polypide tube is seen in the "A" zooecia. In the right-hand upper "B" zooecium the median process extends distally beyond the opening of the polypide tube, it is straight, with projecting angles, and the oral arch is of abnormal form; the one in the "B" zooecium at the base of the specimen being of normal shape.

Steganoporella cliftonensis, n. sp. (Pl. XLIV., Fig 29).

Zoarium encrusting. Zooecia dimorphic, oval, overlapping distally. Cryptocyst occupying nearly half the length of the zooecia, finely perforated. Polypide tube asymmetrical, prolonged distally; median process with flanges connecting poly-

pide tube with the distal margin of cryptocyst and the lateral walls. Oral shelf forming a subtriangular arch in the "B" zoocia, but is hardly perceptible in the "A" zooecia.

"A" zooecia 0.9 to 1.2 mm. long, 0.7 to 0.8 mm. wide .

"B" zooecia 1.5 mm. long, 0.7 to 0.8 mm. wide.

Locality.—Clifton Bank, Muddy Creek (Dr. Hall).

In this species as in *S. lateralis* the polypide tube is asymmetrical, but instead of descending abruptly to the basal wall, as in that species, it extends to a considerable distance distally. In the figure given the zooecium on the left-hand at the top is an "A" form, the others are all "B" zooecia.

Steganoporella corioensis, n. sp. (Pl. XLIV., Fig. 30).

Zoarium encrusting. Zooecia dimorphic, quadrate, arched distally. Cryptocyst in the "A" zooecia occupying about a third of the area; in the "B" zooecia nearly half; in both very finely perforated. Oral shelf in the "B" zooecia forming a subtriangular arch; very narrow in the "A" zooecia. Polypide tube short; median process with flanges connecting it with distal end of cryptocyst.

"A" zooecia 1. to 1.2 mm. long, 0.5 to 0.8 mm. wide.

"B" zooecia 1.3 to 1.4 mm. long, 0.8 mm. wide.

Locality.—Corio Bay (Dr. Hall).

In this species the polypide tube is not exactly in the median line, and is inclined slightly to one side or the other. In the figure the three upper zooecia are of the "B" form, the three lower are of the "A" form.

Steganoporella elongata, n. sp. (Pl. XLV., Fig. 31).

Zoarium probably in vincularian form. Zooecia dimorphic, elongate, arched and overlapping distally. Cryptocyst depressed, finely perforated; median process produced distally as a hemispherical cup, representing the polypide tube, with a sinus on each side. Oral arch in the "B" zooecia forming a subtriangular arch.

"A" zooecia 1. to 1.2 mm. long, 0.4 mm. wide.

"B" zooecia 1.5 to 1.9 mm. long, 0.6 mm. wide.

Locality.—Mornington (Dr. Hall).

This is a small fragment, apparently of vincularian form, not very well preserved, but quite distinct from the other species. The "B" zooecia are very much larger than the "A" zooecia, which latter are much narrower than those of the other species described. The polypide tube shows as a hemispherical cup on a level with the cryptocyst, and there is no indication of its connection with the basal wall.

Thalamoporella airensis, n. sp. (Pl. XLV., Fig. 32).

Zoarium in vincularian form. Zooecia elongate, narrow: margins raised; distal end arched, occasionally pointed. Thyrostome arched above, projecting forward; slightly curved below. Avicularia acute. Ooecia (?) cup-shaped.

Locality:—Aire coastal beds (Dr. Hall).

This is a very narrow celled species, and the zooecia vary a good deal in form and size, some are curved distally, and some, more or less pointed. The avicularium, at the top of the specimen, bears a long, apparently cylindrical, process distally, but it is not very well preserved. On one zooecium on the right-hand side is a cup-shaped process, which is probably the basal part of an ooecium.

Thalamoporella dennanti, n. sp. (Pl. XLVI., Fig. 33).

Zoarium encrusting, flat. Zooecia longitudinally disposed, in straight lines: margins very thin, raised. Cryptocyst flat; surface with a few small scattered pores, chiefly on the lateral margins. Thyrostome arched distally, with very thin upper margin: proximal margin curved and rounded. Ooecia globose, superimposed on the distal zooecia; basal wall with a large central foramen and a small elliptical one on each side.

Locality.—Mitchell River (J. Dennant).

In this species the lateral margins of the zooecia are very thin, and project above the flat cryptocyst: the margins of the thyrostomes are raised, the distal having a thin edge; the proximal one is rounded, and where it is broken is seen to be hollow. Only the basal walls of the ooecia are preserved, showing them to be probably globose.

Cribrilina tenuicosta, McG., sp. (Pl. XLVII., Fig. 34).
Membraniporella tenuicosta, McG.

I have included an illustration of a specimen of this species, as upon it there is an avicularium, which has not hitherto been recorded. I have assigned the species to *Cribrilina*, as it evidently belongs to it. Dr. MacGillivray was himself inclined to do the same.

Aspidostoma otwayensis, n. sp. (Pl. XLVII., Fig. 35).

Zoarium in vincularian form. Zooecia elongated, arched above with a thick, smooth, convex margin, which extends proximally towards the base, leaving the median portion depressed on each side, but slightly elevated in the centre. Thyrostome arched above, curved below, with a narrow lip.

Locality.—Cape Otway (Dr. Hall).

This differs from A. airensis from the Aire coastal beds in the distal margin of the zooecia, not being produced into a conical process, and the absence of a sinus at the angles of the proximal margin of the thyrostome, and the absence of avicularia.

Phylactella bairnsdalei, n. sp. (Pl. XLVII., Fig. 36).

Zoarium encrusting. Zooecia undefined, frontal surface perforated with large, somewhat regularly disposed, elongated pores: two small raised cylindrical processes, with a pore on the summit below the thyrostome; one close to peristome, the other lower down and on one side. Peristome tubular, projecting forwards and upwards, concealing the thyrostome.

Locality.—Mitchell River (J. Dennant).

The specimen is small, only three peristomes are present, and there are no pores upon them. The pores are arranged in more or less regular longitudinal order. This is possibly the species from the same locality alluded to by Dr. MacGillivray as being too imperfect for description.

Monoporella venusta, Eichwald. (Pl. XLVII., Fig. 37).

Lepralia venusta Eichwald. Manzoni. Sitzb. d. mathem-naturw., Cl. lix., Bd. 1., Abth. p. 20 (1869).

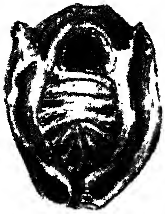
Fig 1.


Fig 2.

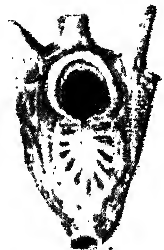
Fig. 3.


Fig. 4.


Fig 5.


Fig. 6.


Fig. 7.


Fig. 8.

Fig. 9.

Fig 9a

Fig 10

Fig. 11.

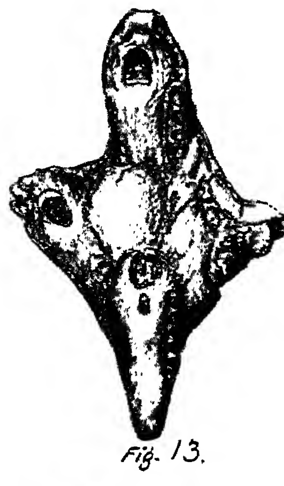

Fig. 13.

Fig. 12

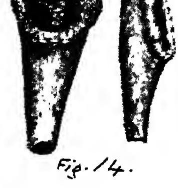

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.

Fig. 19.

Fig. 20.

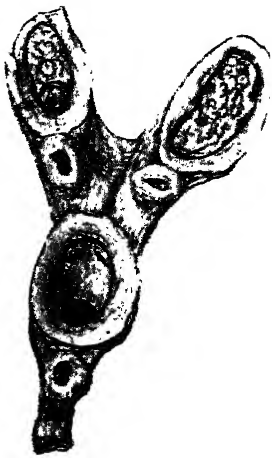

Fig. 21.

Fig. 22.

Fig. 23.

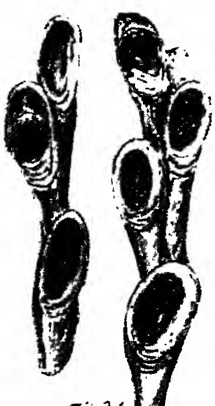

Fig. 24

Fig. 25.

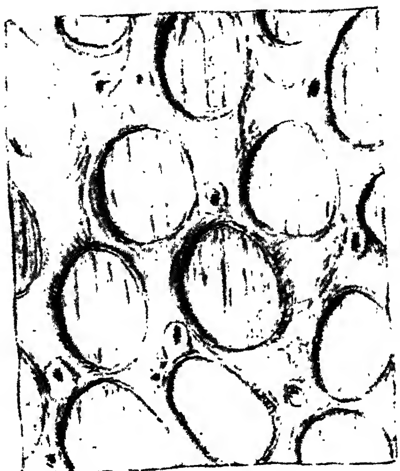

Fig. 26.

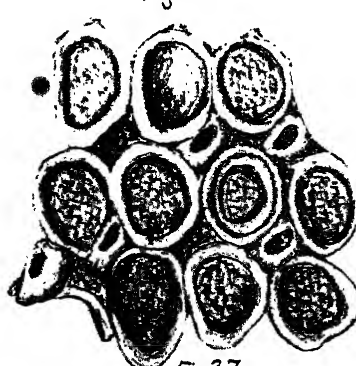

Fig. 27.

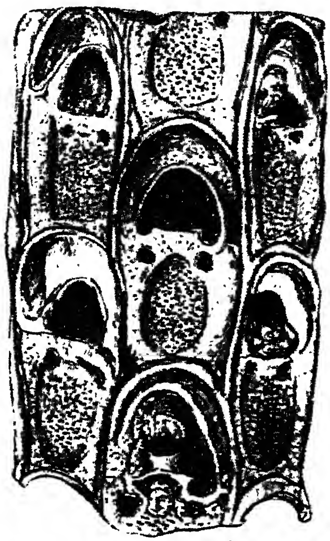

Fig. 28.

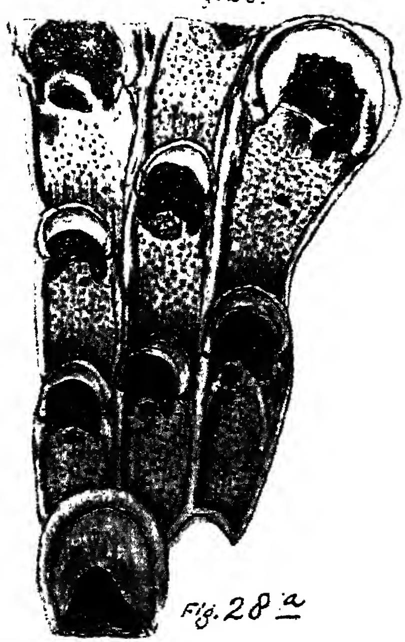

Fig. 28 a

Fig. 29.

Fig 30.

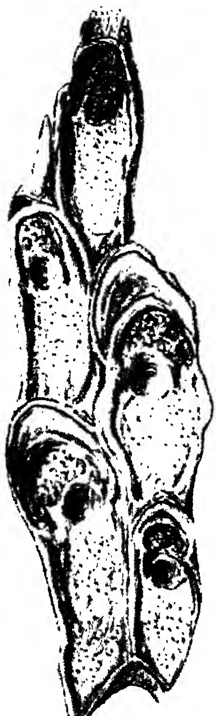

Fig. 31.

Fig 32

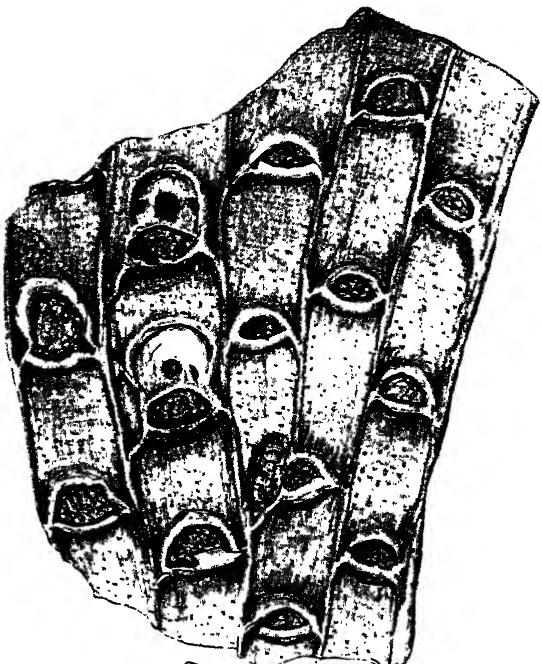

Fig. 33.

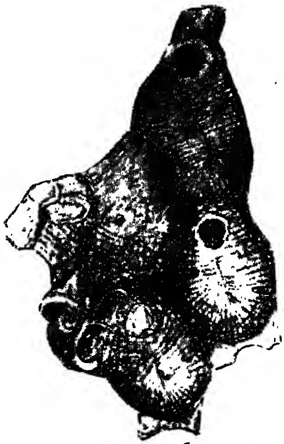

Fig. 34.

Fig. 35.

Fig. 36.

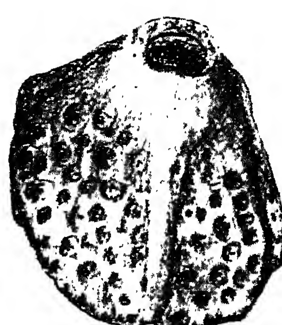

Fig. 37.

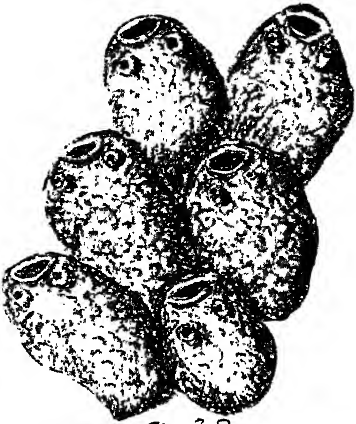

Fig. 38.

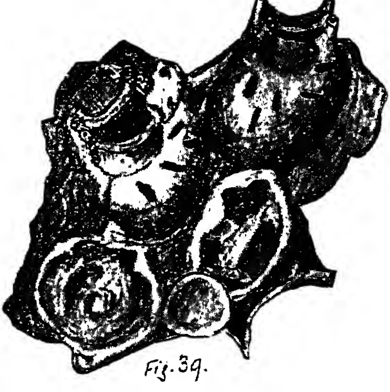

Fig. 39.

Lepralia venusta Eichwald. Lethaea Rossica, vol. iii., p. 29, Tav. ii., fig. 2.

Manzoni, in a paper upon the Italian Pliocene Polyzoa (*Briozoi Pliocenici Italiani*) records, in the reference quoted, the occurrence of this species in Italy. I have not seen the reference to "Lethaea Rossica," which Manzoni quotes in his paper.

The following is a translation of the principal part of Manzoni's description:—"Cells (zooecia) quincuncially disposed, rhombic-ovate, rounded distally, partly punctate; aperture terminal, semicircular or subrotund; peristome elevated, six spines above. Three thick smooth costae, central one attenuated towards the base, lateral ones divergent, surface between the costae irregularly punctate, moderately convex, depressed towards the base." He states the cells (zooecia) are very large, the dimensions being—height 1 mm., width two-thirds of a millimetre.

Locality.—Campbell's Point (J. F. Mulder).

The specimen of this species is upon a slide given to me by Mr. Mulder. It is only an imperfect front wall of a zooecium; it agrees in every respect with Manzoni's description and figure, but only the central costa is present, the lateral ones have been broken off. It is 0.8 mm. long, and if perfect would have been quite 1 mm. long, if not more. The punctations are mostly small hemispherical pits, with a pore in the centre, but in one part they are crowded and quadrate in shape, and there are traces of the six spines on the upper margin of the peristome.

Inversiula airensis, n. sp. (Pl. XLVIII., Fig. 38).

Zoarium encrusting. Zooecia ovoid, surface roughly granulated. Thyrostome transversely elliptical, with the proximal margin more curved than the distal one: a short spinous process, perforated at the summit, on each side below the thyrostome.

Locality.—Wilkinson's No. 4, Aire coastal beds (Dr. Hall).

This species is very near *I. nutrix*, recorded by Jullien[1], but it has not the central "*fenestrule semilunaire*" of that species.

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1 "Cap Horn," p. 44, pl. 4, fig. 8.

Canu, in "Bryozoaires fossiles de l'Argentine"[1], gives a figure of a form which he says is Jullien's species. I do not consider that this is correct, as it has no fenestrule, but it is more nearly allied to *I. airensis*, though it differs from it, as the spinous perforated processes are situated by the side of the thyrostome above the proximal margin, and not below it, as in both *I. nutrix* and *I. airensis*.

Inversiula quadricornis, n. sp. (Pl. XLVIII., Fig. 39).

Zoarium encrusting. Zooecia oval, ventricose: surface perforated with radially, but irregularly arranged, narrow slits. Thyrostome broad, distal margin nearly straight, proximal margin curved; margins thick: two tubular upright cylindrical processes on each side: a lunate, slightly depressed area below. Ooecium globose (?).

Locality.—Wilkinson's No. 4, Aire coastal beds (Dr. Hall).

A small fragment of very peculiar structure. The zooecia are very ventricose, almost globular; the form of the thyrostome is not very distinctly shown, as in the left-hand one, the right-hand margin is obscured by a fragment of calcareous matter, and of the right-hand one there is only a side view. The four tubular processes situated close to the margins of the thyrostome are characteristic. In the lower part of the specimen there is a circular depression surrounded by a raised margin which I consider is the basal wall of an ooecium; the oval depression on the right-hand side is apparently the basal part of a zooecium, but what the small shallow round depression represents is not evident. The whole structure is very unique, but I think it may properly be assigned to *Inversiula*, as the thyrostome has the proximal margin more curved than the distal one, and it has the same kind of tubular spinous processes as the other species have.

These species are of interest because, owing to the proximal margins of the thyrostomes being more curved than the distal, the opercula were probably hinged at the distal, instead of at the proximal, margin, as in almost all other cheilostomata.

1 "Anales del Museo Nacional de Buenos Aires" Tomo xvii. (Ser. 3a. t. X.), p. 283, pl. vi., fig. 8.

EXPLANATION OF PLATES XXXVII.-XLVIII.

Plate XXXVII.

Fig.	1—Catenicella bairnsdalei.			×48.
	2—	„	ampla.	„
	3—	„	cuneiformis.	„
	4—	„	morningtoniensis.	„
	5—	„	concinna.	„
	6—	„	elegantissima.	„
	7—	„	minutissima.	„
	8—	„	longispinosa.	„

Plate XXVIII.

Fig.	9—Strophipora triangularis.			×48.
	9A—	„	„ dorsal surface.	×48.
	10—	„	laevis	×48.
	11—Claviporella bicornis.			„
	12—	„	airensis.	„
	13—Vittaticella cruciformis.			„
	14—Brettia brevis.			„

Plate XXXIX.

Fig. 15—Caberea morningtoniensis. ×77.

Plate XL.

Fig.	16—Farcimia airensis.			×26.
	17—Menipea uniserialis.			×48.
	18—Synaptacella ovalis.			×77.
	19—	„	asymmetrica.	„
	20—	„	gibbosa.	„
	21—	„	crassimarginata.	„

Plate XLI.

Fig.	22—Synaptacella dennanti.			×77.
	23—	„	recta.	„
	24—Cellularia balcomiensis.			×48.
	25—	„	mooraboolensis.	×77.

Plate XLII.

Fig. 26—Membranipora laevissima. × 48.
27— „ ovifera. × 26.

Plate XLIII.

Fig. 28—Steganoporella dennanti. × 26.
28A— „ bairnsdalei. „

Plate XLIV.

Fig. 29—Steganoporella cliftonensis. × 26.
30— „ corioensis. „

Plate XLV.

Fig. 31—Steganoporella elongata. × 26.
32—Thalamoporella airensis. „

Plate XLVI.

Fig. 33—Thalamoporella dennanti. × 26.

Plate XLVII.

Fig. 34—Cribrilina tenuicosta. × 26.
35—Aspidostoma otwayensis. „
36—Phylactella bairnsdalei. „
37—Monoporella venusta. × 48.

Plate XLVIII.

Fig. 38—Inversiula airensis. × 48.
39— „ quadricornis. „

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. II., 1911.]

Art. XXV.—*Contributions to the Flora of Australia, No. 16.*[1]

BY

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AND

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(With Plates XLIX-LVII.)

[Read 13th October, 1910.]

Acacia Kochii (W. V. Fitzgerald, MS.), Ewart and White, n.sp. (Leguminosae). (Pl. XLIX., Figs. 1–5).

Watheroo Rabbit fence, Max Koch, 1905, No. 1616.

A tall shrub, glabrous, with spinescent branches. Phyllodes from .5-1 inch in length, and 1-3 lines broad, slightly falcate, with small pungent points flattened vertically. There is a prominent, almost central vein, and several prominent lateral veins on each side, stipules absent. Peduncles solitary, about ½ an inch long, bearing a small cylindrical spike of about 30-50 crowded flowers.

Flowers 5-merous, sepals united except at the top, where there are 5 somewhat obtuse lobes. Petals at least twice as long as the sepals, free and slightly pointed at the free ends.

Stamens numerous—Fruit much twisted and constricted between the seeds, 2.5-3 inches in length, pointed at both ends.

The species would come in the Series III., Pungentes of Bentham, on account of its possessing phyllodia, spinescent branches and cylindrical inflorescence. This last character would place it into the Sub Series D Spicatae, from which, however, it differs in having 5-merous flowers. In this respect apparently, the definition of the subseries might be extended. Baron von Mueller

1 No. 15 in Proc. Roy. Soc. Victoria, vol. xxiii., Pt. 1, n.s. (1910), p. 110.

placed the sub-section Spicatae under the Juliflorae, which seems on the whole a less artificial arrangement than Bentham's. This species is the only one of the Spicatae sub-section found in West Australia, whereas the remainder of the Juliflorae includes Western as well as Eastern species. The above manuscript name was attached to the specimen by W. V. Fitzgerald, but no description of the plant has hitherto been published.

ACACIA LEPTONEURA, Benth., var. EREMOPHILA, Ewart and White (A. EREMOPHILA, W. V. Fitzgerald, MS.).

(Pl. L., Figs. 1–4).

Cowcowing, West Australia, Max Koch, 1904, No. 1024a.

The principal characters in this new variety are:—Shrubs 1½-2 feet high, the young stems closely covered with woolly grey hairs. Phyllodia almost terete, but slightly flattened, glabrous, about 2 inches long, with small recurved points.

The inflorescence is almost sessile, and composed of 10-15, 5-merous flowers. Sepals rectangular, united about half their length. Petals free, obtuse, smooth. Ovary sessile, nearly glabrous. Pods (only seen when young) ¼-1 inch in length, and less than 1 line in breadth, very much twisted and covered with dense woolly grey hairs; not constricted between the seeds.

This specimen was made into a new species by W. V. Fitzgerald, but no technical description has been published hitherto.

The chief difference between it and Bentham's description of *leptoneura* is that there are fewer flowers in the head than in the typical *A. leptoneura*, and hence the heads are smaller. The No. 1338a, of Max Koch appears to be typical *A. leptoneura*, but has no fruits.

Of two fruiting specimens placed under *A. leptoneura* by Baron von Mueller, one (Mt. Jackson, Young, 1875), has pods 6 centimetres long, by about 2 millimetres broad, not or very slightly constricted between the seeds, the other (Mrs. Heal, Swan River, 1890), has pods 3 or 4 centimetres long, little more than a millimetre broad, and strongly constricted between the seeds. This was at first considered the type of a new species, but subsequently placed by Mueller under *A. leptoneura*. If so, it represents a well-marked variety, but both these fruiting speci-

mens are without flowers, and hence their correct identification is uncertain.

ACACIA EWARTIANA (W. V. Fitzgerald, MS.), White, n. sp. (Pl. L., Figs. 5–7).

Cowcowing, West Australia, Max Koch, 1904, No. 998.

A shrub 2-3 feet high.

Stems nearly terete, glabrous.

Phyllodia nearly terete, somewhat curved with several longitudinal veins, rigid, usually $\frac{1}{2}$-$\frac{3}{4}$ inch in length, rather obtuse at the tip, where there is a small straight or very slightly hooked pungent point, distinctly articulated on the stem. Scattered stipules either absent or deciduous. The heads are very small and globular, measuring about 1 line in diameter, and composed of about 10 small 5-merous flowers, axillary. solitary, on slender pedicles of 1-1$\frac{1}{2}$ lines in length. Bracts broad, pointed at the ends, brown.

Sepals only united at the extreme base, not exceeding half the length of the petals, obtuse, edged with short processes. Petals united about $\frac{1}{2}$ their length, the 5 lobes being rather smooth, obtuse.

Stamens numerous. Ovary sessile, glabrous. Fruit not seen.

Acacia Ewartiana seems to fall under Series III. Pungentes (Benth.), except that the phyllodia are slightly obtuse.

It apparently comes nearest to Acacia striatula, but differs in the following characters.

(1.) The branches are not minutely pubescent.

(2.) The phyllodia are not tapering.

(3.) The flowers are not numerous on the heads.

(4.) The midribs are not prominent in the petals.

ALOE ARBORESCENS, Miller. (Liliaceae). "Tree Aloe."

Mentone, Miss A. Tovey, July, 1910.

Growing as a garden escape on the railway line at Mentone. It is a native of South Africa, and bears a handsome spike of red flowers.

Angianthus lanigerus, Ewart and White, n. sp. (Compositae).
(Pl. LI., Figs. 1–5).

Wooroloo, Max Koch, 1907, No. 1873.

Herbs 4-8 inches in height, stems freely branching, especially towards the top, glabrous when old—when young covered with dense white woolly hairs. Leaves .5-1 inch long, sessile, linear, pointed, but expanded and slightly ensheathing at the base, more or less covered with white hairs, alternate. Inflorescence solitary, axillary, 2-3 lines in diameter, ovoid-convex, surrounded by an involucre of foliose, lanceolar, rather pointed bracts, which are covered with white woolly hairs, and have very small membranous margins, and are about 2 lines in length, being longer than the florets. There is an inner circle of flat, membranous bracts, which are obtuse, and provided at the top with a tuft of hairs, and have a very small foliose portion in the centre.

Partial heads 1-flowered surrounded by 3 membranous bracts all of which are lanceolar, obtuse at the top, where also there is a tuft of hairs, and all are more or less concave. The pappus is absent, and the florets are pale yellow in colour, and 5-merous, and not thickened at the base except as the fruit begins to ripen, when the base becomes very slightly thickened. Achenes slender, pale in colour, about one-third the length of the floret, somewhat tapering at the base.

The species seems to be nearest to *Angianthus strictus*, to which it was referred as a variety in the Contributions to the Flora of Australia, No. 12 (Proc. Roy. Soc. of Victoria 22, 1909, p. 92). It differs in the following respects:—

(1.) The bracts surrounding the compound head are broader and much less pointed.

(2.) The whole inflorescence is much more woolly.

(3.) The number of bracts surrounding each partial head is 3 (rarely 4), instead of 2.

It has been referred to *A. Preissianus* by another botanist, but differs from that species in the following respects:—

(1.) The plant is much larger and more vigorous, and branches more freely.

(2.) The bracts of the partial heads are more concave, and each has a fringe of hairs on the upper margin.

(3.) The florets have not the thickened base of *A. Preissianus*.

(4.) The partial heads are always 1-flowered.

(5.) There is no pappus.

(6.) The florets are 5-merous.

(7.) The achene is much more slender, longer and lighter in colour.

ASPLENIUM FURCATUM, Thunb. (Filicineae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1927.

AUSTRALINA PUSILLA, Gaud. (Urticaceae).

The plant is given in the last Census as from Victoria, Tasmania, New South Wales and Queensland. This is because Mueller considered *A. pusilla* and *A. Muelleri*, Wedd., to form one species. They are undoubtedly distinct. *A. Muelleri* occurs in Tasmania, Victoria, New South Wales, and possibly also in Queensland, although no Queensland specimens have been seen, and Bailey gives it as from Queensland on Mueller's assertion alone. *A. pusilla* is confined to Tasmania of the Australian States, although it is also found in New Zealand.

BANKSIA INTEGRIFOLIA, L.fil. (Proteaceae).

Mt. Redman, Grampians, A. G. Campbell, Sep., 1910.

Smooth leaved forms on exposed highlands from 2500 feet, forms with leaves mainly with serrated edges at 1500—2500 feet in gully heads.

BANKSIA MARGINATA, Cav. (Proteaceae).

Mt. Redman, Grampians, edge of highland morass, A. G. Campbell, Sep., 1910.

(The leaf often closely resembles that of *B. collina*, which is recorded from Mt. Ararat, and is distinguished by its larger flowers and strongly hooked styles.)

BARTSIA TRIXAGO, L. (Scrophulariaceae). "Trixago Bartsia."

Near Newstead, County of Talbot, F. M. Reader, 31/10/1909.

A new locality in Victoria for this naturalised alien. Previously recorded from Broadmeadows.

BORONIA DENTICULATA, Sm. (Rutaceae).

Donnybrook, West Australia, Max Koch, Oct., 1909. No. 1934.

The specimen has the larger sepals and more umbellate inflorescence of *B. fastigiata*, Bartl., but has the longer pedicels of *B. denticulata.* Other specimens join these two species, and justify Mueller's inclusion of *B. fastigiata* as a variety of *B. denticulata.* The distinctive features are the inflorescence, leaves and sepals, all of which are variable and occur in various combinations.

CALADENIA LATIFOLIA, R.Br., var. GLANDULA, Ewart and Wood, new var. (ORCHIDACEAE).

Lowden, Preston River, West Australia, Max Koch, Nov. and Dec., 1909. No. 1944.

The plant is somewhat more hairy and the leaves are shorter and narrower. The chief differences, however, are in the flowers. The perianth segments are dotted closely on the outer surface with brown glandular hairs, especially towards the ends, and they are more blunt than in the type *Caladenia latifolia.* Owing to the lesser number of hairs, the veins show up more clearly on the perianth of *Caladenia latifolia.* The labellum in each is three-lobed, but in the variety, the middle lobe is shorter than that of the type, and its margin is distinctly crenate. The flowers are pale yellow instead of pink or white, as in the type.

CALADENIA PATERSONI, R. Br., var. DILATATA. (Orchidaceae).

Lowden, Preston River, West Australia, Max Koch, Oct. 1909. No. 1930.

CALOCEPHALUS SKEATSIANA, Ewart and White. (Compositae).

Mr. Max Koch writes that the habit of this plant is quite prostrate, the numerous branches are flat on the ground.

CONYZA SCABIOSAEFOLIA, Remy. (Compositae). "Rough Conyza."

Government House Reserve, April, 1897, J. R. Tovey ; Elsternwick, July, 1910, Gordon Parker.

This plant is a native of Chili, and appears now to be definitely established as a naturalised alien in the Melbourne district. It was originally identified by Mr Luehmann as *Conyza aegyptiaca*, Aiton., a native of North Australia and Queensland, as well as of Asia and Africa. It differs from that species in the involucre, indumentum, leaves and achene. The plant appears to have originally escaped from the Botanical Gardens, its pappus bearing seeds being readily carried by the wind.

COTULA AUSTRALIS, J. Hook. (Compositae).

Lowden, Preston River, West Australia, Max Koch, Sep., 1909, No. 1929.

COTULA CORONOPIFOLIA, L. (Compositae).

Lowden, Preston River, West Australia, Max Koch, Sep., 1909, No. 1936.

DARWINIA CITRIODORA, Benth. (Myrtaceae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1941.

EREMOPHILA MERRALLI, F.v.M. (PHOLIDIA COERULEA, Spencer le Moore). (Myoporineae). (Pl. LIII., Figs. 1–3, 7).

The first name is given in the Kew Index, but occurs as a nomen nudum without description in the Victorian Naturalist, vol. ix., p. 63, 1892. The unpublished manuscript description attached to the specimen by Mueller, is given beneath:—

"Vestiture copious, consisting of ramified spreading hairlets: leaves small, crowded, sessile, somewhat semi-cylindric, blunt, bearing on the lower side hemispherically protruding resinous glandules: flowers small, singly sessile, in the axils of leaves towards the end of the branches; segments of the calyx almost linear, acute, lanuginous: corolla twice or thrice as long as the

calyx upwards blue, near its base suddenly cylindrical narrowed outside, rather sparsely beset with soft hairlets inside, at and towards the lowest lobe bearing long tender intricate hairlets, the two upper lobes deltoid, the two lateral lobes ovate-semi-lanceolar, the lowest lobe more roundish, stamens all shorter than the corolla, their anthers bluish; style nearly glabrous; ovulary densely beset with white appressed hairlets."

Eremophila Merralli is quite distinct from the type *Eremophila gibbosifolia* (pl. liii., f. 4-6). The calyx of *Eremophila gibbosifolia* is glabrous, whereas that of *Eremophila Merralli* is densely hairy. Also the corolla of the latter is sparsely beset with hairlets outside, and inside the few branching hairlets are found near the lower lobe, the lateral lobes are almost acute, and the two upper lobes are small and deltoid.

The corolla of *E. gibbosifolia* is glabrous outside, and inside the lower lobe bears a dense soft mass of hairlets.

The fruits differ in shape and hairness, as shown on the plate. The fruit of *E. Merralli* is a bi- tri- or quadrilocular drupe, with one seed in each loculus, a thin fleshy mesocarp, and a hard stony endocarp.

The Elder expedition specimen, as well as the *Pholidia coerulea* of Spencer le Moore, which he considers to be the same plant, seem to resemble *Eremophila Merralli* closely, and the former specimen was, in fact, labelled by Baron von Mueller as *E. Merralli.* The calyx is less hairy, and in this respect Spencer le Moore's specimens, which were distinguished by him as a separate species "*Pholidia coerulea,*" show an approach towards *E. gibbosifolia,* but the difference is hardly sufficient for the recognition of a distinct species or even variety. The question of priority is a matter of some difficulty in this case, assuming *Pholidia* and *Eremophila* to be interchangeable, but Mueller's name has been accepted in the Kew Index, as well as at the National Herbarium for many years, and it is possible a description may have been published in some out-of-the-way publication, although no record of it can be found.

Wangering, West Australia, R. Helms, 14/11/91 (Elder exploring expedition). Parker's Range, West Australia, E. Merrall, 1891; L. Deborah, near Mt. Moore, 1889, E. Merrall; Gibraltar, West Australia, S. Le Moore, Oct., 1895.

ERIOSTEMON LINEARIS, Cunn. (Rutaceae).

Cowcowing, West Australia, Max Koch, Oct., 1909, No. 1231. New for West Australia, only known previously from South Australia and New South Wales. Mueller, in his later years, evidently considered this to be a variety of *E. difformis*, A. Cunn., but the species differ in several respects, particularly in the leaves and inflorescence.

ERYNGIUM ROSTRATUM, Cav. (Umbelliferae).

Lowden, Preston River, West Australia, Max Koch, Sep., 1909. No. 1593.

GASTROLOBIUM SPINOSUM, Benth. (Leguminosae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1940.

GREVILLEA OXYSTIGMA, Meissn. (Proteaceae).

Lowden, Preston River, West Australia, Max Koch, Sep., 1909. No. 1948.

HAKEA SULCATA, R. Br., var. INTERMEDIA, Ewart and White, new var. (Proteaceae).

Cowcowing, West Australia, Max Koch, 1904. No. 1056.

This variety seems to be nearest to *Hakea sulcata*, var. *scoparia*, from which it differs, however, in being of a more slender type, in having less sulcate leaves, and in possessing a prominent ridge round the stigmatic cone.

In this last respect, it resembles the typical *H. sulcata* from which, however, it differs in the following characters:—

(1.) The leaves are much longer, and are not so prominently sulcate.

(2.) The pedicels usually slightly exceed 1 line in length.

(3.) The hypogynous gland is much longer and more conspicuous.

HALGANIA LEHMANNIANA, Sond. (Boraginaceae).

In the Contributions to the Flora of Australia, No. 13 (Proc. of the Royal Soc. of Vict., vol. xxii., p. 321), after *Halgania Lehmanniana*, Sond., for (Solanaceae), read (Boraginaceae).

HIBBERTIA MONTANA, Steud., var. CONFERTIFOLIA, (Dilleniaceae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1950.

HYPOCALYMMA ROBUSTUM, Endl. (Myrtaceae).

Donnybrook, Preston River, West Australia, Max Koch, Sep., 1909. No. 1949.

JUNCUS BUFONIUS, L. (Juncaceae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1938.

JUNCUS HOMALOCAULIS, F. v. M. (Juncaceae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1939.

LABICHEA PUNCTATA, Benth (Leguminosae).

Lowden, Preston River, West Australia, Max Koch, Sep., 1909. No. 1947.

LINUM ALBIDUM, Ewart and White, n.sp. (Linaceae). "Rodway Flax." (Pl. LIV., Figs. 1, 2, 4).

Western mountains, Tasmania, 4000 feet altitude, L. Rodway.

A glabrous herb from about 6 inches to 1.5 feet high. Stems slender, upright, and rather ribbed, with few basal leaves. Leaves 2 lines to half-an-inch length, alternate, lanceolate, pointed, exstipulate, sessile, but slightly ensheathing and narrowed at the base.

Inflorescence as in *Linum marginale*, forming a loose irregular,terminal corymb. Sepals 2-3 lines long, ovate, lanceolate, acuminate, with a narrow scarious margin as in *L. marginale*, but they differ from this species in not possessing a very prominent midrib, the sepals have a more rugose surface, and a broader membranous base.

Petals white, about twice as long as the sepals.

Stamens 5 united into a basal ring, the 5 staminodia being represented by minute points attached to the ring, alternating

with the stamens and opposite the petals. Ovary similar to that of the L. marginale, but a little more convex at the top. Style about half-a-line in length, and the branches only united about ¼ of their length, the free parts radiating, and with a slightly pappulose terminal stigma on each. Fruit a superior capsule, dividing into 5 cocci, with 2 small flat seeds in each compartment. The plant does not appear to agree with any non-Australian Linums. It was found in a district not invaded by aliens, and was sparingly distributed over an area of some miles. There seems to be no doubt that it represents an undescribed species of very restricted range, and is of especial interest as forming an addition to a genus represented in Australia by a single endemic species.

LINUM GALLICUM, L. (Linaceae). "Yellow Flax."

Cheltenham, Dec., 1873; Warragul, Gippsland, 1904; H. B. Williamson.

This European Flax with small yellow flowers was recorded in Bentham's Flora as naturalised in New South Wales round Parramatta (also Sydney), but has not previously been recorded for Victoria.

LINUM GRANDIFLORUM, Desf. (Linaceae). "Splendid Flax."

Barrier Range, New South Wales, E. Wehl, 1887.

Probably only a garden escape.

LOGANIA SERPYLLIFOLIA, R. Br. (Loganiaceae).

Lowden, Preston River, West Australia, Max Koch, Sep.-Nov., 1909. No. 1932.

MONOTAXIS OCCIDENTALIS, Endl. (Euphorbiaceae).

Lowden, Preston River, West Australia, Max Koch, Sep.-Nov., 1909. No. 1946.

PASCALIA GLAUCA, Orteg. (Compositae). "Pascalia."

Ascot Vale, Melbourne, O. Youngman, Aug. 1910.

This plant, a native of Chili, has hitherto only been recorded from the Railway Reserve at North Melbourne. It is evidently

naturalising itself in the Melbourne district. It does not appear to be either actively useful or actively injurious, but is useless for fodder, and has no known economic or poisonous properties.

PORANTHERA HUEGELII, Klotz. (Euphorbiaceae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1943.

SAGINA APETALA, L. (Caryophyllaceae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1928.

SARGA, Ewart, new genus. (Gramineae).

Spikelets one-flowered on filiform pedicels, in groups of 3. One hermaphrodite spikelet being situated below 2 male spikelets, the rachis of each group of 3 spikelets being articulated below the glumes of the hermaphrodite spikelet; the part of the rachis above the articulation forming a sharp-pointed stipe to the fruit.

Glumes 3, the two outer unawned, and hardened when the fruit is ripe, the flowering glume membranous and awned in the hermaphrodite flower, unawned in the male flowers.

Awn dorsal and persistent, and bent about one-third of its length from the glume, the part below the bend being spirally twisted.

Stigma lobes covered all over with rather long processes.

Caryopsis narrow, and enclosed in the persistent, hardened sterile glumes.

The genus belongs to the group Agrostideae (Engler and Prantl). Owing to its having a membranous flowering glume, it falls under sub-group B, and under the section d of Engler and Prantl's Pflanzenfamilien, because the stigmatic lobe have processes situated all round them. It belongs to the same Sub-section as the genus Limnas, from which, however, it differs in the following important respects:—

(1.) In height and general habit Limnas is a short, slender type of grass.

(2.) All the spikelets in Limnas are hermaphrodite, and they do not occur in definite groups of 3.

(3.) The awn is short.

(4.) In Limnas, the style branches are united above the middle of their length.

The fact that the classification adopted for the Agrostideae brings these two widely dissimilar grasses close together is sufficient to show its artificial character. The fruit of Sarga shows much external resemblance to that of Stipa. This would be still further increased by the loss of the lateral male spikelets and their stalks, leaving the short pointed disarticulating common stalk as the basal point of the Stipa fruit. The latter is, however, within the outer glumes in Stipa, but below them in Sarga, so that the two mechanisms are morphologically dissimilar, in spite of their homoplastic resemblance.

This feature, and the readily separated awn of Sarga, thus shows the beginnings of a parallel development of the dispersal mechanism, so highly perfected in Stipa. On Bentham's classification, the grass would form the type of a new sub-section "Sargaceae" intermediate between the Stipaceae and Agrostideae, and with the following characters:—

"Spikelets one-flowered, two male spikelets, and a single hermaphrodite one, on a common stalk: awn long, dorsal, loosely attached, twisted and bent: fruiting glume thin, but the fruit enclosed by the outer hard persistent glumes, and the persistent pedicels of the male flowers, hairs present on the pointed axis below the articulation of the 3 spikelets."

SARGA STIPOIDEA, Ewart and White, n. sp. (Gramineae). (Pl. LV., Figs. 1–7).

Stems very long, round, solid, with swollen nodes, attaining 5 to 8 or 10 feet in height, and 4 to 10 cms. in diameter; apparently perennial at the base—erect, glabrous, with conspicuous nodes. Leaves about 4 lines in breadth, with a very prominent central midrib, glabrous on the upper surface, but very slightly hairy underneath, with short split sheaths at the base, and longer ones enclosing the stem higher up. Ligule small, membranous, the notch between it and the stem filled with hairs.

Panicle loose, about 1 foot or a little more in length, pedicels very slender and numerous, situated in whorls along the main

axis 1-5 inches apart, and closer towards the top. The common pedicel to each group of 3 spikelets about 2-6 inches, bearing terminally a hermaphrodite spikelet and 2 lateral male spikelets on stalks of slightly unequal length. The common pedicel above the oblique pointed articulation, possesses comparatively long silky white hairs, which turn brown when the fruit is ripe, the stalks of the 2 male spikelets are edged with a row of similar hairs, are broader than the common pedicel and are slightly flattened. There are 2 keel-shaped empty, unawned, sterile glumes in both kinds of spikelets, about 3 lines long, and covered externally with soft white hairs. In the hermaphrodite spikelet, they are rather hard and rigid, and wrapped round the gynaecium, and their extremities are blunt and shortly bilobed. In the male spikelets, they remain more or less membranous, and their extremities are acuminate.

There is one transparent, flowering glume, which, without the awn, is about ¾ the length of the outer glumes. The twisted awn is attached to the back of the flowering glume near the base, is sharply bent, measures 3-4 inches in length, and is hairy at the edges.

The Pale is membranous, transparent, 2-nerved, a little shorter than the flowering glume.

Stamens 3, similar in both kinds of flower.

Ovary free from the glume, styles 2, very fine, united for about ¼ of their length—1-1½ lines long.

Stigmas about 1 line long, pointed at the end.

Fruit surrounded by the persistent glumes, which are dark brown, shining, and almost glabrous when the fruit is ripe, and also by the persistent, flattened pedicels of the male spikelets.

Caryopsis about 2 lines long. Starch grains simple and compound, but mostly simple.

Prince Regent's River, North-West Australia, Bradshaw and Allen, 1891; Napier, Broome Bay, North-West Australia, G. F. Hill, 18/5/10. No. 161.

This large and striking grass, with almost cane-like stems and solid internodes, filled with loose pith, comes from a district hitherto little explored, and may possibly be only locally distributed. It is apparently a semi-aquatic reed-like grass. The leaves and young shoots seem to be nutritious, and the loosely

awned fruits would be less obnoxious than those of *Stipa.* The stems are, however, too hard to be of much use for fodder, though softer and more slender in young plants.

SCHOENUS ODONTOCARPUS, F. v. M. (Cyperaceae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1937.

SOLANUM NUMMULARIUM, Spencer le Moore (Journ. Linn. Soc., 34, p. 205), = S. ORBICULATUM, Dun. (Solanaceae).

This is a somewhat dwarfed form of the above species. The characters relied on to distinguish it—rustiness of tomentum, smaller flowers with narrower corolla lobes, smaller leaves, and more pointed anthers—vary independently of each other on certain specimens. The Elder exploring expedition specimens from Fraser Range and L. Deborah, have these characters united, as in Spencer le Moore's specimen, and were placed by Tate and also by Mueller under *S. orbiculatum.* That from the Victorian Desert Camp, 54, has the rusty tomentum combined with large leaves (up to 1 inch in length and breadth), and large flowers, but relatively narrow corolla lobes. On most specimens the leaves are less than ½ inch long.

STYLIDIUM ALSINOIDES, R. Br., var. CORDIFOLIUM. (Stylideae). (Pl. LVI.).

This plant has been considered by certain West Australian botanists as a distinct species, on the basis of the following features:—

Branches, angled or winged, leaves cordate, or ovate and sessile, the two lower calyx segments connate to above the middle, and the segments of the corolla also more united. These are, however, all independently variable characters, the most marked tendency being to the sessile cordate leaves, thus justifying the recognition of a variety with various intermediate forms, but not of a distinct species.

Various localities in West Australia, also in North Australia, Port Darwin, M. Holtze, 1890. No. 1171. And in North-West

Australia, Isdell River, Graces Knob, Messmate Creek in Packhouse Range, between Isdell Range and Mt. Bartlett.

The figures on the plate are all of *S. alsinoides*, with the exception of that on the right, which represents the variety *cordifolium*.

The name "*Stylidium*" was altered by Baron von Mueller to "*Candollea*," the plants under this genus in the Dilleniaceae being transferred by him to *Hibbertia*. The original change of *Candollea* (1805) to *Stylidium* (1806), was accepted by Labillardiere, and all the species described under that name by Labillardiere, and all subsequent authors, including Mueller, up to 1873. The synonymy on which Mueller proposed to upset the established nomenclature has been shown in Engler's Pflanzenfamilien (III., 8, p. 260), to be incorrect, or at least doubtful.

STYLIDIUM CILIATUM, Lindl. (Stylideae).

On sand plains, Lowden, Preston River, West Australia, M. Koch, Oct., 1909. No. 1931.

STYLIDIUM CRASSIFOLIUM, R. Br. (Stylideae).

In swamps, Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1942.

STYLIDIUM ELONGATUM, Benth. (Stylideae).
(Pl. LVII., Fig. 1–10).

The central figure in the plate is a fairly close reproduction of Bentham's original specimen. The degree of hairiness of the flower axis varies, as also does the length of the corolla lobes, their margins, the shape of the labellum, and the appendages.

S. elongatum var. *glabricaule*, F. v. M. (pl. LVII., fig. 11-14) has a glabrous scape, a more pointed labellum, and no appendages to the corolla, besides being a taller, stouter form almost worthy of specific rank. Various localities in West Australia.

STYLIDIUM REDUPLICATUM, R. Br. (Stylideae).

On rocks, Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1933.

TILLAEA MACRANTHA, Hook. (Crassulaceae).

In moist places, Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1935. New to West Australia.

TILLAEA PEDICELLOSA, F. v. M. (Crassulaceae).

Kangaroo Island, A. J. Campbell, Dec., 1905. Apparently unrecorded for the island.

TRICORYNE ELATIOR, R. Br. (Liliaceae).

Lowden, Preston River, West Australia, Max Koch, Oct., 1909. No. 1945.

VERTICORDIA CUNNINGHAMI, Schau. (Myrtaceae).

Napier, Broome Bay, West Australia, G. F. Hill, 14/10/1909. No. 3. And 22/5/1910. No. 192.

In old flowers, the style projects to a length of a centimetre beyond the flowers.

VERTICORDIA HELMSII, S. le Moore. (Myrtaceae).

This plant, described by S. le Moore in Journal of the Linnean Society, vol. 34, p. 190, was classed by Baron von Mueller as a variety *V. picta*, Endl. (*V. picta var Youngii*). Though close to that species, its elevation to specific rank seems justified by the obtuse leaves, smaller petals and flowers, glabrous style, etc. No intermediate forms appear to occur.

Additional localities are:—Between Victoria Spring and Ularing, Jesse Young, Oct., 1875; Golden Valley, 1888, and near Mt. Moore, 1889, West Australia, E. Merrall; Victoria Desert Camp 57, R. Helms, Sept., 1891.

XEROTES FIMBRIATA, F. v. M. (Liliaceae).

Cowcowing, West Australia, Max Koch, Dec., 1904. No. 1014.

EXPLANATION OF PLATES XLIX-LVII.

Plate XLIX.—Acacia Kochii, Ewart and White.

Fig. 1.—Portion of a branch. Natural size.
2.—Leaf. Natural size.
3.—Inflorescence. Natural size.
4.—Flower. Enlarged.
5.—Fruit. About twice the natural size.

Plate L.—Acacia leptoneura, Benth. var eremophila, Ewart and White, and Acacia Ewartiana, White.

Fig. 1.—Small portion of flowering branch of *A. leptoneura* var. *eremophila*. Natural size.
2.—Flower of same. Enlarged.
3.—Gynaecium of same. Enlarged.
4.—Young fruit of same. Twice natural size.
5.—Small portion of flowering branch of *A. Ewartiana*. Natural size.
6.—Flower of same. Enlarged.
7.—Gynaecium of same. Enlarged.

Plate LI.—Angianthus lanigerus, Ewart and White.

Fig. 1.—Small portion of a flowering branch. Natural size.
2.—Outer bract from involucre. Enlarged.
3.—Inner bract from involucre. Enlarged.
4.—Concave bract surrounding partial head. Side view Enlarged.
5.—Single floret.

Plate LII.—Caladenia latifolia, R. Br. var. *glandula*, Ewart and Wood; and C. latifolia, R. Br.

Fig. 1.—Plant of *Caladenia latifolia* var. *glandula*.
2.—Flower of same.
3.—Labellum of same.
4.—Labellum of *Caladenia latifolia*. Type form.
5.—Flower of same.

PLATE LIII.—EREMOPHILA MERRALLI, F. v. M.; and E. GIBBOSIFOLIA, F. v. M.

Fig. 1.—Portion of plant of *Eremophila Merralli.*
2.—Flower of same.
3.—Corolla of same cut open.
4.—Flower of *Eremophila gibbosifolia.*
5.—Section of fruit of same.
6.—Section of fruit of *Eremophila Merralli.*
7.—Fruit of *Eremophila gibbosifolia.*
8.—Fruit of *Eremophila Merralli.*

PLATE LIV.—LINUM ALBIDUM, Ewart and White, and LINUM MARGINALE, Cunn.

Fig. 1.—Flower with petals removed. Enlarged.
2.—Gynaecium. Enlarged.
3.—Gynaecium of *Linum marginale.* Same scale as 2.
4.—Upper part of a plant. Natural size.

PLATE LV.—SARGA STIPOIDEA, Ewart and White.

Fig. 1.—Small portion of panicle, from which most of the spikelets have dropped off. Natural size.
2.—Very small portion of leaf. Magnified.
3.—Characteristic group of 3 spikelets. Magnified.
a. common pedicel.
b. hermaphrodite spikelet.
c. stalk of male spikelet.
d. Male spikelets.
4.—Male spikelet opened. Magnified.
a. Sterile glumes.
b. Flowering glume.
c. Pale.
d. Anther.
5.—Hermaphrodite spikelet opened. Magnified.
a. sterile glumes.
b. flowering glumes.
c. Pale.
d. Anther.

e. Stigmatic globe.
f. Awn.

6.—Gynaecium of hermaphrodite flower. Greatly magnified.
7.—Fruiting spikelet. Magnified.
a. Pointed end of common pedicel.
b. persistent stalks of male spikelets.

PLATE LVI.—STYLIDIUM ALSINOIDES, R.Br.

Fig. 1.—Entire plant.
2.—Flowering branches.
3.—Flower.
4.—Tip of flower enlarged.
5.—Apex of column. Front view.
6.—Apex of column. Back view.
7.—Longitudinal section of ovary.
8.—Apex of same, cut through septum.
9.—Seed.
10.—*S. alsinoides*, var. *corditolium.*

PLATE LVII.—STYLIDIUM ELONGATUM, Benth. (Figs. 1-10). (Stylideae).

Fig. 1.—Entire plant.
2.—Young flower
3.—Flower from front with labellum appendage and a bract at the back.
4.—Flower at back.
5.—Labellum.
6.—Glandular hairs.
7.—Portion of leaf, back and front.
8.—Back and front view of apex of column.
9.—Vertical section of ovary.
10.—Seed magnified.

S. ELONGATUM var. GLABRICAULE.

Fig. 11.—Apex of scape.
12.—Flower from front.
13.—Labellum.
14.—Apex of column, back and front view.


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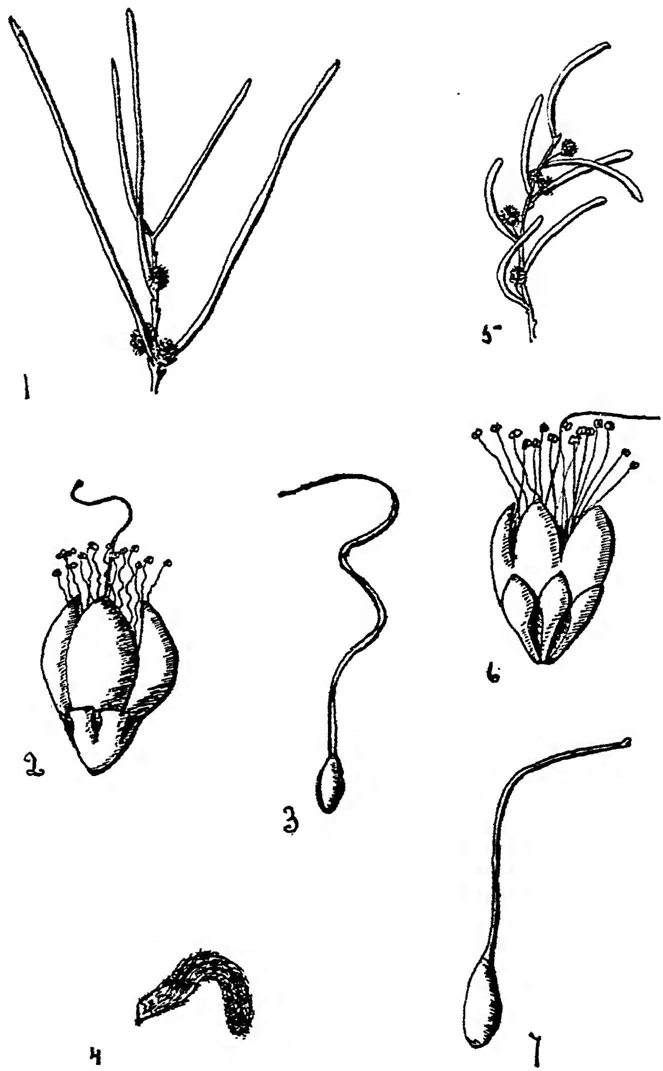

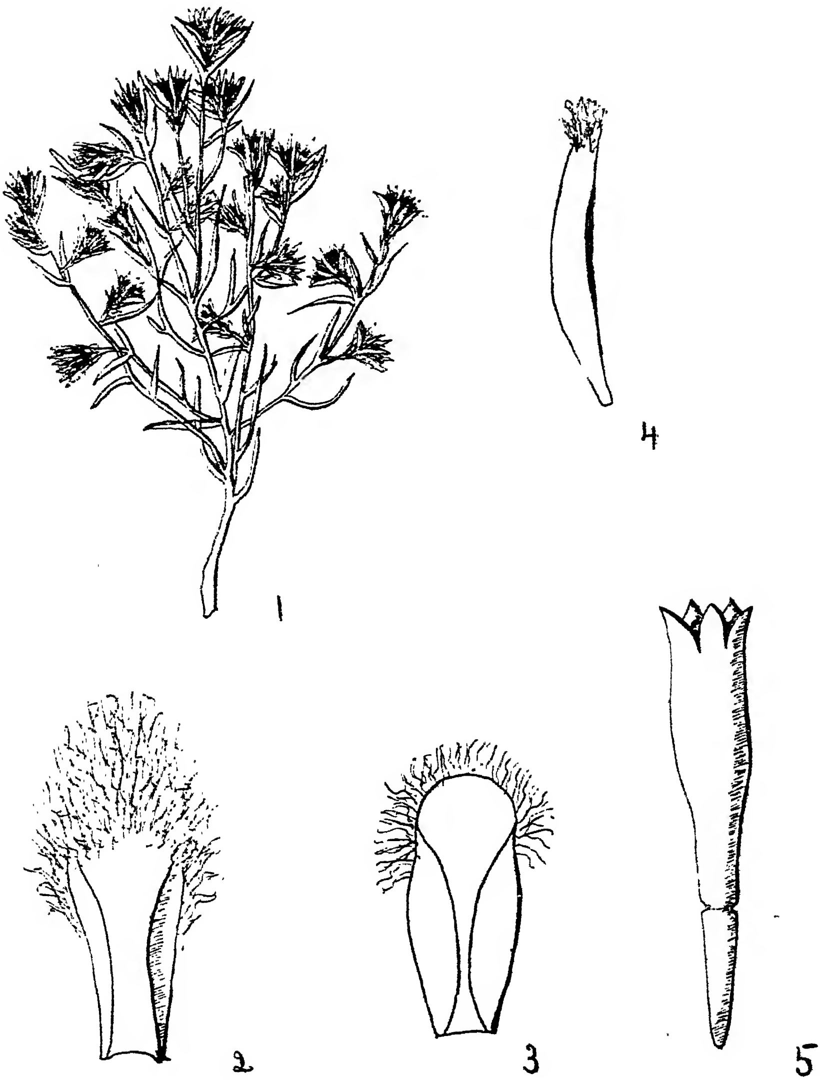
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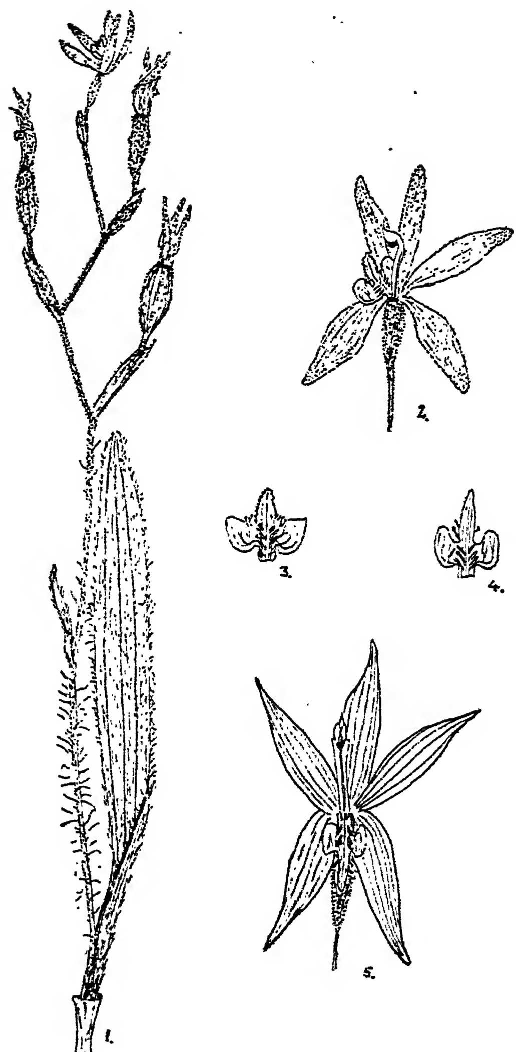
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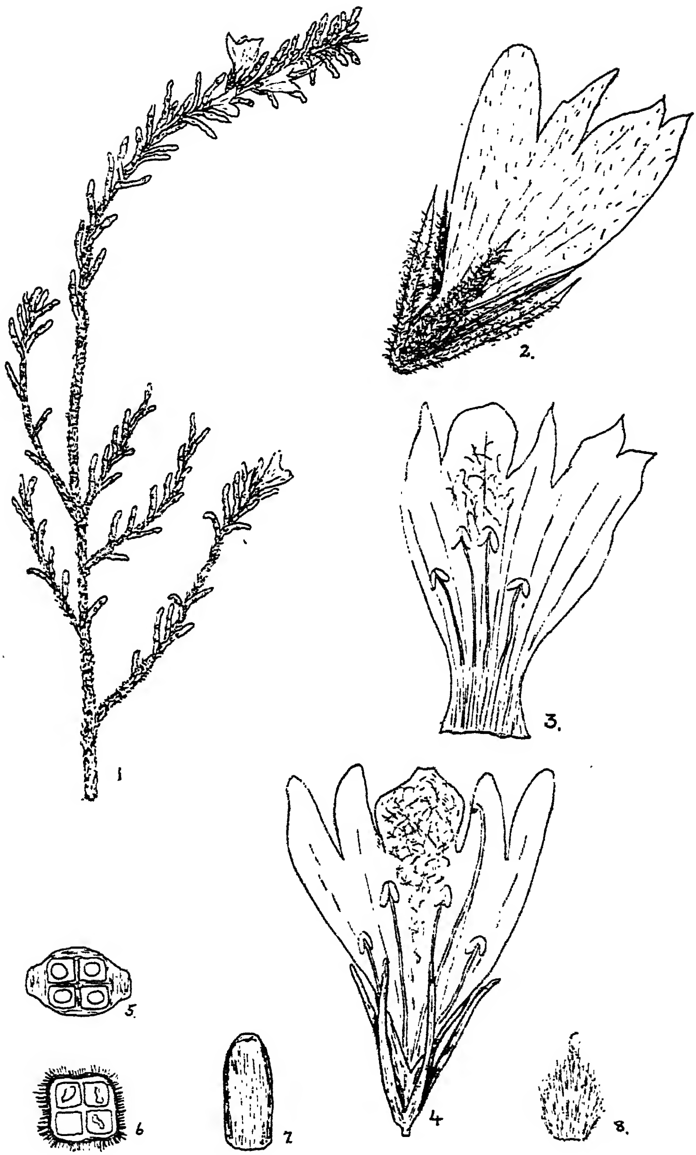
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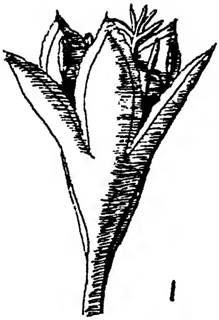

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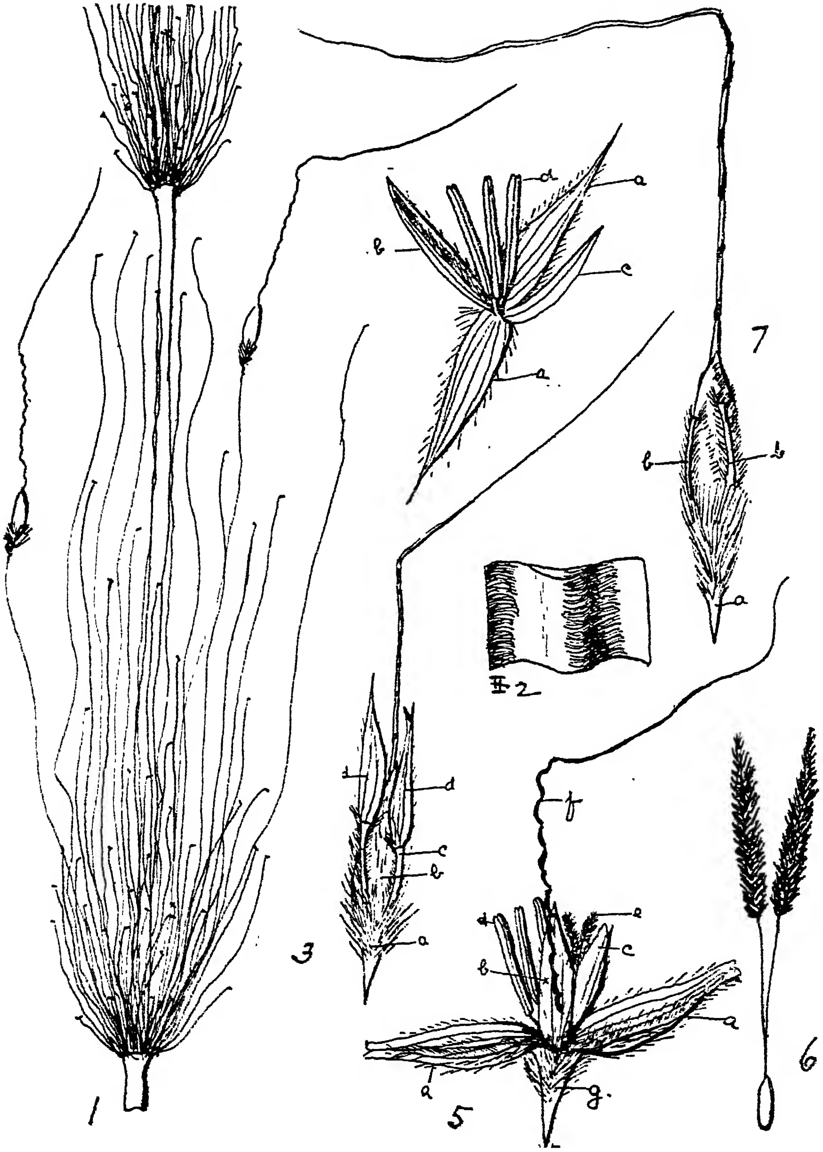

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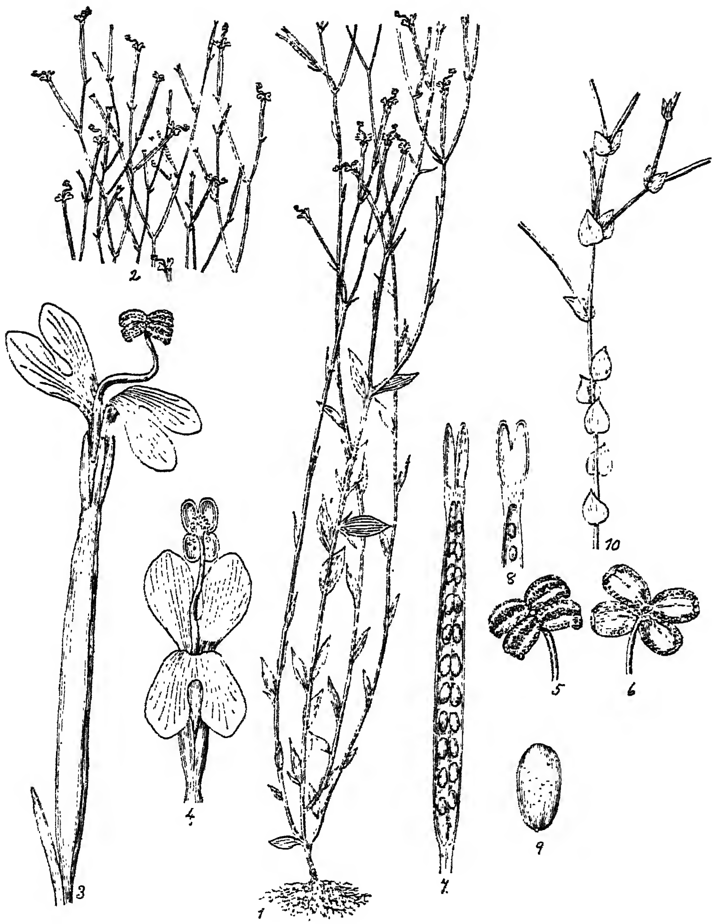
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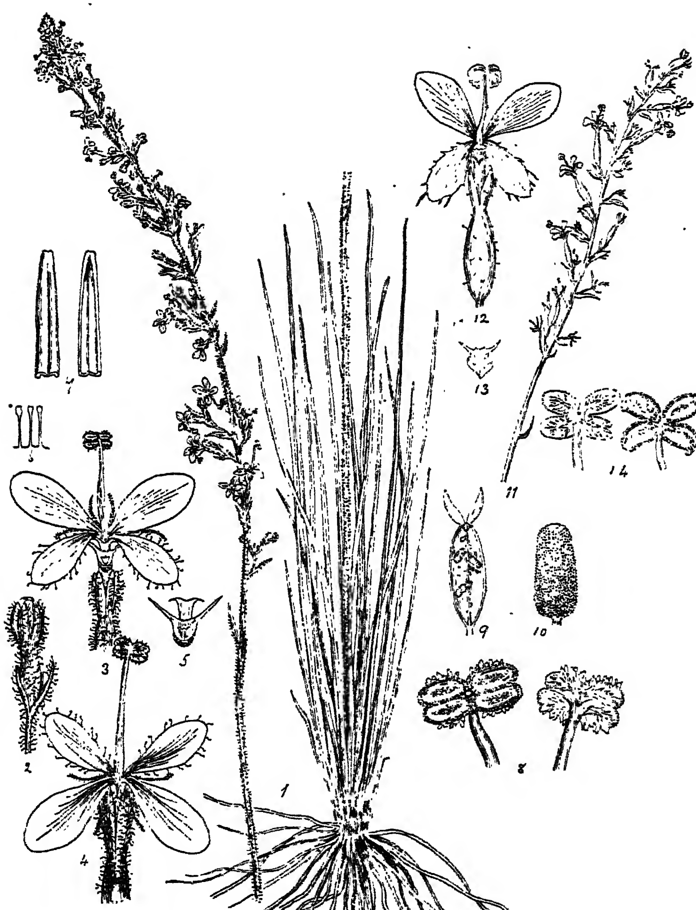
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[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. II., 1911.]

ART. XXVI.—*New or Little-Known Victorian Fossils in the National Museum.*

PART XII.—ON A TRILOBITE FAUNA OF UPPER CAMBRIAN AGE (OLENUS SERIES) IN N. E. GIPPSLAND, VICTORIA.

BY FREDERICK CHAPMAN, A.L.S., &c.

(Palaeontologist to the National Museum, Melbourne).

(With Plates LVIII.-LXI.)

[Read 13th October, 1910.]

Introduction.

A preliminary note has already been written[1] touching briefly upon this interesting collection of fossils, which were obtained by Mr. E. O. Thiele, B.Sc., F.G.S., from the Dolodrook River in the Mt. Wellington District of N.E. Gippsland. In that note the writer recorded the occurrence of *Agnostus*, together with some, at that time, doubtful portions of opisthoparian trilobites, of which only parts of the cephala and the pygidia were preserved. The latter specimens, it was then suggested, might possibly belong to (?) *Cheirurus* and (?) *Proetus*. An exhaustive examination of these fragments, of which there are many, has shown, however, that the two doubtful forms last mentioned really belong to *Crepicephalus* and *Ptychoparia*, both of which are generic types of strong Cambrian affinities. Further than this, the prolific remains of *Agnostus*, of the type of *A. pisiformis*, practically fix the age of the trilobite limestone as Upper Cambrian.

The pale grey crystalline limestone, found in apparently the same belt as the dark grey trilobite rock, contains brachiopods and a (?) *Girvanella*. The brachiopods are somewhat large for Cambrian forms, and belong to the group *Plectorthis*. This subgenus of *Orthis* has not been found below the Lower Ordovician in the North American region, where it is best known; but in

1 F. Chapman. Proc. Roy. Soc. Vic., vol. xvi. (n.s.), pt. i., 1908, pp. 268, 269.

Great Britain one of its members, *O.* (*Plectorthis*) *hicksii*, Davidson, is a characteristic fossil of the Middle Cambrian (Menevian Beds). In China the same type of shell is seen in *O. linarssoni*, Kayser, from the rocks of Ta-ling. This species of brachiopod is found, according to C. D. Walcott, in both the Middle and Upper Cambrian faunas of China.[1]

The brachiopod limestone was found at a spot close to Roan Horse Gully, a tributary of the Dolodrook River, whilst the trilobite limestone occurred on the Dolodrook River at the western end of the belt.[2] Regarding the stratigraphy of the exposures of limestone, Mr. Thiele has remarked as follows[3]:—"These rocks occur as a number of small lenticular outcrops along a line conforming in general to the strike of the [Upper] Ordovician rocks, and a short distance away from the serpentine belt, on its south-western side." The bed of limestone at Roan Horse Gully is referred to by Mr. E. J. Dunn[4] as follows:—"It appears to be resting on the serpentine. It may belong to the series of beds exposed at the junction of Thiele's Creek and Dolodrook Creek, where there is another outcrop. A third outcrop occurs a few chains above the junction of Black Soil Gully with Dolodrook Creek, on the west side of the latter creek. These limestone outcrops all appear to be of the same age, and the last-mentioned is said to be traceable at intervals for a mile in a south-west direction." Mr. Dunn further remarks:—"The sedimentary beds now stand at an angle of 80 deg. to 85 deg."

In view of the present discovery of undoubted Cambrian rocks in Victoria, it will be interesting to examine at a later date some further evidence, lately obtained, regarding the Heathcote (Knowsley) trilobite fauna; as well as that of certain fossils obtained near Mansfield doubtfully referred to the Cambrian. Respecting the Knowsley trilobites, Mr. R. Etheridge has already given copious notes[5] regarding the relationship of *Dinesus* to

1 Proc. U.S. Nat. Mus., vol. xxix., 1906, pp. 4, 5.

2 Consult map in O. E. Thiele's "Notes on the Dolodrook Serpentine Area and the Mt. Wellington Rhyolites, North Gippsland." Proc. Roy. Soc. Vict., vol. xxi. (n.s.), pt. i., 1908, pl. xi., facing p. 268. The trilobite occurrence is there marked L. 1, and the brachiopod limestone L. 4.

3 Loc. supra cit., p. 263. See also Vict. Nat., vol. xxiv., 1907, p. 26, where Mr. Thiele states that the limestone is surrounded by the graptolites slates.

4 Rec. Geol. Surv., vol. iii., pt. 8, 1909, p. 68.

5 Proc. Roy. Soc. Vict., vol. viii. (n.s.), 1896, p. 60.

Dorypyge, a typical Cambrian genus, to which the former seems quite closely allied; and latterly Mr. C. D. Walcott has also remarked[1] on the relationship, stating that *Dinesus* of Eth., jnr. (the pygidium of which is now referred by Prof. J. W. Gregory to *Notasaphus*)[2] appears to be more nearly related to *Dorypyge*, Dames, than to *Damesella* or *Dorypygella*, Walcott." The genus *Dorypyge* is found throughout the Cambrian, and, in China, also occurs in a bed above the *Agnostus* zone.

With regard to the affinities of the Liau-tung fauna, which shows some points in common with that of the Mt. Wellington limestones, Dames considers it to correspond with the Scandinavian Andrarum Limestone, and to the lowest division of the Potsdam Sandstone in America.[3]

General Characters of the Limestones.

The trilobite-bearing limestone is dark bluish grey in colour, and partially crystalline. The samples collected by Mr. E. O. Thiele are crowded with the remains of these crustacea, chiefly parts of the cranidia, with an occasional pygidium of the larger forms; whilst the heads and tails of *Agnostus* are found scattered pretty freely over the fractured surfaces of the rock. Several fragments of the thoracic pleurae, presumably of *Ptychoparia* and *Crepicephalus*, can be distinguished, but no connected pieces were obtained. Evidently the membrane connecting the elements of the thoracic region was excessively delicate and easily separated.

In thin sections under the microscope the trilobite limestone is seen to be practically calcitic, having a coarsely crystalline structure. (See Pl. LX., Fig. 25.) The matrix contains innumerable sections of the trilobite carapaces cut in all directions. The latter are usually encrusted on both upper and under surfaces by a thin layer of a black carbonaceous substance of a granular texture, commonly seen in trilobites that are at all well preserved. The thickness of these fragments of trilobite

1 Proc. U.S. Nat. Mus., vol. xxix., 1906, p. 35.

2 Proc. Roy. Soc. Vict., vol. xv. (n.s.), pt. ii, 1903, p. 155, pl. xxvi., figs. 11, 12a, 12b, 13.

3 Dames, in Richthofen's "China," vol. iv., 1883, p. 28. See also H. Woodward, Geol. Mag., 1905, pp. 212, 213.

tests varies from .05 to 1 mm. Numerous fine cracks and fissures traverse the limestone in all directions, and are filled generally with a black granular substance, which in this case may be a basic mineral infilling, such as one of the sulphides. Otherwise the limestone is fairly pure, and no quartz grains were noticed in the sections examined.

The limestone found near Roan Horse Gully, which consists largely of (?) *Girvanella* pellets in a fine-grained matrix, and also contains brachiopoda and joints of crinoids, is much paler than the trilobite limestone, and generally of a light grey colour. (See Pl. LX., Fig. 26.) This rock, also, has a nearly pure calcitic composition; and there is a marked absence of the black carbonaceous and other matter so abundant in the darker limestone. No trilobite fragments were noticed in this rock, but it appears, nevertheless, to be merely a different lithological condition in the same geological stage.

Systematic Description of the Fossils.[1]

Plantae.

Class Algae.

Genus *Girvanella*, Nicholson and Etheridge fil., 1880.

(?) Girvanella, sp. (Pl. LX., Fig 23, Pl. LXI., Fig. 26).

Observations.—A hand specimen of grey limestone, rather paler in colour than the trilobite rock, is composed largely of ovoid pellets formed by an enwrapping or encrusting organism like *Girvanella.* One of these pellets measures as much as 15 mm. in length. This rock was mentioned in a previous note published in 1907,[2] when the limestone was ascribed to the Silurian, partly on account of the prevalence of that form elsewhere in Victoria in beds of similar age; and also because of the *Platystrophia*-like Orthid, accompanying it. The latter fossils are here shown to be distinct from *Platystrophia*

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1 Mr. E. O. Thiele, B.Sc., F.G.S., who collected these specimens, has kindly presented them to the National Museum, Melbourne.

2 Vict. Nat., vol. xxiv., p. 34.

biforata, being smaller and not so spiriferoid in shape. The pellets forming this rock were described in the note above referred to as follows:—"These form a large part of some of the limestones, perhaps as much as 40 or 50 per cent., but their intimate structure has been entirely removed by secondary crystallisation, and only traces of the concentric mode of growth can be seen, together with a nucleus of a shell-fragment or crinoid joint."

There is now little doubt that the *Girvanella* and trilobite limestones occur in or near the same stratigraphical horizon, and that the former may be older than was originally thought from the field and palaeontological evidence. Another and similar specimen of *Girvanella* limestone was subsequently obtained by Mr. E. J. Dunn, F.G.S., Director of the Geological Survey, from Roan Horse Gully, Wellington River, and this was reported upon by the writer in 1908.[1] The pellets were there referred to as being from 5 to 6 mm. in length, and crinoid ossicles were seen in the rock in great abundance.

These *Girvanella* limestones are of a good blue-grey colour, and would make a handsome marble for ornamental purposes when polished.

Horizon.—Upper Cambrian. Brachiopod Zone. Roan Horse Gully.

ANIMALIA.

Class CRINOIDEA.

Crinoid stem-joints and ossicles, indet. (Plate LIX., Figs. 16 *a*, *b*., 17 *a*, *b*.)

Description.—Two isolated specimens of stem-joints were obtained from the pale grey limestone by fracture.

A.—A series of eight conjoined infranodals, very low; forming part of a stem circular in section; the axial canal pentagonal or rosette-form; articular facets indistinctly radially striate, and slightly crenulate at the margin. Diameter, 4 mm.; total height, 3.1 mm. (Fig. 16, *a*, *b*.)

1 Rec. Geol. Surv. Vict., vol. ii., pt. iv., p. 211.

B.—Probably a nodal columnar joint; with a rounded periphery, but inclined to be subpentagonal in outline; axial canal pentagonal; area around perforation depressed on both facets, and having five distinct grooves from axis to margin; surface smooth, tumid between the radial grooves. Diameter, 5.25 mm.; height, 2.6 mm. (Fig. 17 *a, b.*)

Some ossicles (? arm-joints) are found forming the nuclei of the (?) *Girvanella* pellets, but these also are obviously of an indeterminate character.

Observations.—In the Appendix to the chapter on the Crinoidea in Eastman-Zittel's Text-book of Palaeontology,[1] it is stated that "Crinoidal fragments have been detected in the Cambrian, but consist of stem-joints only (*Dendrocrinus*)."

In their "Revision of the Crinoidea" Messrs. Wachsmuth and Springer[2] give, in the diagnosis of *Dendrocrinus*, "Column pentagonal, or exceptionally round." They record all the species, except one from the Niagara Group, in the Lower Ordovician (Trenton Limestone). The stem of *Dendrocrinus cylindricus*, Billings,[3] is of the same general form as our fragmentary specimens indicate, but further comparison is impossible, since the indispensable portion, the crown, is not represented in our series, except by isolated (?) brachials, seen only in sections of the pellets.

Horizon.—Upper Cambrian. Brachiopod Zone. Roan Horse Gully.

Class Brachiopoda.

Genus *Lingulella*, Salter, 1861.

(?) **Lingulella**, sp, (Pl. LIX., Fig. 13).

Description and Affinities.—The shell is ventral, and shows the impression of a broad pedicle canal on the denuded umbo. It is ovately pentagonal in outline, with slightly divergent sides, and widely curved anterior margin. There is no dorsal valve to indicate its inaequivalve condition or otherwise, but the width

1 Vol., 1900, p. 177.
2 Proc. Acad. Nat. Sci. Philad., 1879, p. 298.
3 Geol. Surv. Can.-Canadian Organic Remains, dec. iv, 1859, p. 44, pl. iii., figs. 8*a*, *b*.

of the pedicle channel points to *Lingulella* as the probable genus. The surface ornamentation is in parts well preserved, and consists of strong concentric growth lines, crossed by fainter radial lines, after the manner of *Lingulella davisii*, McCoy,[1] of the Lingula Series of Great Britain, which species it also resembles in outline but not in size, being much smaller. A species of *Lingulella*, which Kayser compares with *L. nathorsti* Linarsson, has been figured by the former author[2] from the Cambrian of the Liau-Tung Peninsula (China). It resembles our specimen in shape, but does not possess any radial striae, such as are clearly seen in our example.

Dimensions.—Length, 3.4 mm.; width, 2.75 mm.

Occurrence.—A single valve adhering to the glabella of *Ptychoparia thielei.*

Horizon.—Upper Cambrian. Agnostus Zone. Dolodrook River.

Genus *Orthis*, Dalman, 1827.

Sub-genus *Plectorthis*, Hall and Clarke, 1892.

Orthis (Plectorthis) platystrophioides, sp. nov.

(Pl. LIX., Figs. 14, 15).

Description.—Shell of medium size, transversely oval; strongly costate. Hinge-line as long as the entire breadth of the shell; cardinal extremities produced or ending in an acute angle. Dorsal valve semicircular, transversely elongate, moderately and evenly convex, with a faint sinus bearing two costae. Pedicle valve deeper, strongly convex on the median fold, and depressed towards the cardinal angles. Beak prominent and incurved. Area moderately wide, triangular; delthyria large, open; dorsal or brachial valve with a conspicuous cardinal process. Surface of valves with 16-20 strong plicae, with an occasional finer riblet interposed between the primary ones. Faint indications of concentric growth-lines or transverse plicae, with one or two strongly emphasised growth-stages.

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1 McCoy. Brit. Pal. Foss., 1852, p. 252, pl. i.-l., fig. 7.

2 In Richthofen's "China," vol. iv., p. 35, pl. iii., fig. 3

Dimensions.—Width, about 13 mm.; length of dorsal, about 8 mm.; length of ventral valve, about 9 mm.

Note.—One example of a pedicel valve accompanies these specimens, which otherwise are very uniform in size, and which perhaps may be regarded as a senile form of the species. It measures about 17 x 20 mm.; the costae are slightly finer and more numerous, about 30, but are of the same character as those on the smaller and more typical examples. This shell has a broad, shallow sinus.

Observations.—These specimens from near Roan Horse Gully were previously confused with *Platystrophia biforata*, Schlotheim sp., on account of their strongly spiriferoid shape and stout costae with bifid character.[1] Their occurrence, moreover, in a limestone of uncertain age, resembling the Deep Creek limestone, which had already yielded that species, seemed to support that conclusion. Owing to the discovery of an undoubted Upper Cambrian fauna in limestones associated with the brachiopod bearing rock, these fossils have been re-examined and further cleaned of matrix. The group *Plectorthis*, to which these brachiopods belong, is characterised by having biconvex shells and strongly plicate valves. This group is hardly to be distinguished from certain members of the feebler costate forms of *Platystrophia*, excepting in the longer cardinal process, which in the latter is short and stout.

Affinities.—The present species bears relationship to several British forms, notably of Lower Ordovician and Middle and Upper Cambrian facies. In the transversely elongate form of the valves and their extended cardinal angles, comparison may be made with *Orthis alata*, Sowerby.[2] The character of the costate ornament is allied to that of *O. hicksii* (Salter), Davidson,[3] but the ribs are not so numerous as in our species; whilst the latter has a smoother shell-surface. The fold and sinus is not so pronounced as in *Platystrophia biforata*, Schlotheim sp.,[4] although the large example previously mentioned approaches it

1 F. Chapman. "On Some Fossils from Silurian Limestones, Dolodrook Valley, Mt. Wellington, Victoria." Vict. Nat., vol. xxiv., June, 1907, p. 34.

2 Davidson. Mon. Brit. Sil. Brach., No. 3, 1869, p. 232. pl. xxxiii., figs. 17-21.

3 Tom. supra cit., p. 230, pl. xxxiii., figs. 13-16.

4 See Davidson. Mon. Brit. Sil. Brach., No. 4, 1871, p. 268, pl. xxxviii., figs. 11-25; Hall and Clarke, Pal. of New York—Pal. Brach., pt. i. 1892, p. 200, pl. v.*b*, figs. 1-10.

in these respects. Another species of the same sub-generic type is *O.* (*Plectorthis*) *linarssoni*, Kayser,[1] from the Cambrian of Scandinavia and China. This form, although allied to ours, is not so strongly convex, and differs in the appearance and arrangement of the costae.

The present species differs from the Upper Cambrian orthids of Tasmania indentified by R. Etheridge, junr. as *Orthis lenticularis*, Wahlenberg sp.,[2] in having a biconvex shell. The latter species appears to belong to the genus *Orthis* sensu stricto, and the brachial valve in that form is nearly flat. Etheridge in his description especially mentions that the Tasmanian specimens are not allied to *O. hicksi*, whereas ours clearly show an affinity with that species.

Class Gasteropoda.

Genus *Scenella*, Billings, 1872.

Scenella tenuistriata, sp. nov. (Pl. LIX., Figs. 18*a*, *b*).

Description.—Shell small, subconical; aperture ovate; apex eccentric, obtuse, slightly incurved towards the longer extremity. In side view boldly convex from apex to margin on shorter side; on longer side concave under the apex, then becoming convex and meeting apertural margin almost vertically. Surface relieved with a few delicate subradial striae inclined towards the longer side, otherwise smooth.

Dimensions.—Length, 2.75 mm.; width, 2.4 mm.; height, 1.6 mm.

Affinities.—Practically all the described species of the above genus are from the Middle Cambrian; but there is an undescribed species from the Upper Cambrian (Potsdam Sandstone) of Wisconsin mentioned by C. D. Walcott[3] which may be at least allied with our form, as that author compares it with

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1 *Orthis hicksii* (Salter), Dav. aff. Linarsson, 1875, Brach. of the *Paradoxides*-beds of Sweden,—Bihang till Svenska Vet. Akad. Handl, bd. iii., No. 12, pl. iii., figs. 22, 23. *O. linarssoni*, Kayser, 1883, in Richthofen's "China," vol. iv., p. 34, pl. iii., fig. 1.

2 Rec. Aust. Mus., vol. v., No. 2, 1904, p. 101, pl. x., figs. 5-9.

3 Bull. U.S. Geol. Surv., No. 30, p. 127.

(?) *Scenella varians*,[1] a species from the Middle Cambrian of the United States and Canada, resembling our fossil in some particulars. The related genus *Stenotheca* occurs in the Cambrian of South Australia, and is distinguished from the above genus by its stronger, rugose shell and curved beak. The latter feature is not emphasised to any degree in our specimen, and the smoother shell shows it to be distinct from *Stenotheca* in that respect.

Horizon.—Upper Cambrian. Agnostus Zone. Dolodrook River.

Class Crustacea.

Sub-class *Trilobita.*

Genus *Agnostus*, Brongniart, 1822.

Agnostus australiensis, sp. nov.

(Pl. LVIII., Figs. 9, 11. 12).

Description.—Head subquadrate, margin narrow. Glabella conical, narrow, bilobed; anterior lobe small, pointed in front, half as long as the posterior; posterior lobe wider and subrectangular; basal lobes small, sub-triangular. Cheeks elevated, surface dull, relieved by very faint radial striae; not so elevated as glabella, and of nearly equal width except in region of anterior glabellar lobe, where they are wider.

Thorax not well preserved in our specimens; portions of lateral and axial elements somewhat crushed, but apparently rather wide.

Tail broad, sub-circular, with a narrow margin produced into short spines at the posterior angles; axis moderately wide, anterior segment narrow, almost bilobed by the intrusion of the middle segment which is anteriorly produced and bearing a strong central tubercle; posterior segment large, elliptical or guttate, being produced behind into a blunt point. Lateral lobes of uniform width, except where confluent behind the pos-

1 Op. cit., p. 127, pl. xii., figs. 2. 2a.

terior segment. Occasional faint tubercles and striae are seen both on the lateral lobes and axis.

Dimensions.—Head-shield (small specimen); length, 2.5 mm.; width, 2.75 mm. Tail-shield: Length, about 4.5 mm.; width, 5 mm.

Affinities.—This form is closely related to *Agnostus pisiformis*, Linné, sp., and is therefore embraced in the section Longifrontes of Tullberg.[1] In general shape and structure it resembles *A. pisiformis* (typica),[2] especially in the form of the cephalon; but in the breadth of the pygidium it is most like the variety of that species named *obesus* by Belt.[3]

Robt. Etheridge in his "Fossils of the British Islands,"[4] includes *A. pisiformis* under *A. princeps*, Salter, together with Belt's variety *obesus*, and gives the horizons as Lingula Flags and Tremadoc. On the other hand Lake, in his later and more critical work,[5] states that Salter's *A. princeps* was founded on specimens of three distinct species—viz., *A. trisectus*, Salter, *A. pisiformis*, L. sp., and *A. rudis*, Salter. To revert to Lake's determinations of *A. pisiformis* var. *obesus*, and its horizon, that author gives the latter as Lower Lingula Flags, but adds, "In some cases the horizon is given as Menevian, in others Upper Lingula Flags, but these determinations may be doubted."[6] It will therefore be seen that the nearest allied form to our species, as occurring in Britain, is typical of the Upper Cambrian or Olenus Fauna.

Another species with which comparison may be made is *Agnostus punctuosus*, Angelin,[7] a species found in the Paradoxides fauna (Menevian). This form differs, however, in the closely tuberculated surface of the head and tail, and also in the less tumid cheeks and pygidial lobes.

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1 See P. Lake. Mon. Brit. Cambrian Trilobites, Pal. Soc., 1906, pp. 2, 3.

2 *Battus pisiformis*, L. sp., Hisinger, 1837, Leth. Suec., p. 19, pl. iv., fig. 5 (figured head downwards). *Agnostus pisiformis*, L. sp., Angelin, 1852, Pal. Scand., p. 7, pl. vi., fig. 7. Lake, Mon. Brit. Camb. Trilobites, 1906, p. 9, pl. i., fig. 12.

3 Belt. Geol. Mag., vol. iv., 1867, p. 295, pl. xii., figs. 4*a-d*. Lake, loc. cit. p. 9. pl. i., figs. 13, 14.

4 Vol. i., Palaeozoic, 1888, p. 40.

5 Loc. cit., p. 12.

6 Loc. cit., p. 10.

7 Angelin, Pal. Scand., 1852, p. 8, pl. vi., fig. 11. Lake, loc. cit., p. 4, pl. i., figs. 4-6.

Agnostus chinensis, Dames,[1] is another species allied to ours. It was described from the Cambrian beds of the Province of Liau-Tung, China. This species shows the same general characters as ours, but in *A. chinensis* the lateral lobes of the tail-shield are not so wide, thus agreeing more nearly with *Agnostus pisiformis;* and moreover, the pygidial axis is not so bluntly pointed posteriorly.

Horizon.—Upper Cambrian, Agnostus Zone, Dolodrook River.

Genus *Ptychoparia*, Corda, 1847.

Ptychoparia thielei, sp. nov.[2]

(Pl. LVIII., Figs. 2, 3, 5, 7, and 10).

Description.—Head-shield large, comparatively broad in front. Glabella large and tumid, elongate and tapering somewhat towards the front; more than two-thirds the entire length of head; surface finely tuberculate, marked by about four pairs of lateral furrows, almost or quite continuous. Palpebral lobes sub-lunate, prominent; eye-lobes very narrow, not conspicuous. Facial sutures strongly curved at the eye-margin, turning at a sharp angle anteriorly, directed forward and outward, and then gently inward to the anterior margin, which it meets a little nearer the central line than the eye; from the posterior end of each eye the suture curves gently outwards, then extends horizontally, and finally is directed obliquely to meet the lower border of the strong genal spine. The cephalic border is finely wrinkled and tuberculate; whilst the prominent areas of the free cheeks are radiately wrinkled.

Thoracic segments fragmentary; none in position.

Pygidium semicircular, rounded posteriorly; moderately large, with about eight distinct segments. Surface finely tuberculate. Axial lobe elevated, rounded, extending to the posterior border; width at the anterior region equalling about one-third of the lateral lobes; the latter depressed or only slightly convex.

Dimensions.—Width of cephalic shield to bases of spines (approximate), 59 mm.; length through the central axis, 15.5

1 In Richthofen's "China," vol. iv., 1883, p. 27, pl. ii., figs. 18, 19.

2 Named in honour of its discoverer, Mr. E. O. Thiele, B.Sc., F.G.S.

mm. Length of pygidium (Fig. 10), 9 mm.; width, about 15 mm.; length of axial lobe, 8 mm.; anterior width of ditto, 3.75 mm.; width of margin, about 1 mm.

Observations.—The material in the present series of limestone specimens shows only the cephala and pygidia preserved, the thoracic portions being disarticulated and so damaged as to make it difficult to decipher more than a few isolated pleurae. There is very little doubt about the pygidia here regarded as belonging to the cephala of *Ptychoparia*, as they show similar superficial tuberculations, and by their numerous segments they show further relationship to that genus. Notwithstanding the variability of form in species of this and other related trilobite genera, it seems advisable to regard the specimens represented by Figs. 1, 4 and 6 as parts of a distinct form, next described.

Affinities.—The large cephalon, with its conico-cylindrical glabella and wrinkled border, shows the relationship of the above species to *Ptychoparia*. It is a member of the Olenidae on account of its large free cheeks, which cut the anterior margin but do not meet, but is naturally separated from *Olenus* on account of its tapering glabella and its large pygidium; and from *Olenellus* by the absence of a pygidial spine. The glabella of *Ptychoparia thielei* closely resembles that of "*Olenellus* sp." of Mr. Etheridge, junr.; a species from the Cambrian of South Australia.[1] Of that form only an imperfect cranidium was found. Etheridge, in his description of this fossil, mentions the genus *Ptychoparia*, but thinks that the evidence indicates *Olenellus* rather than that genus. With the additional evidence of the associated pygidia in our species the comparison may be worth further consideration.

The cranidium of *Olenellus* (?) *forresti* (Eth., junr., MS.), from the Cambrian of Western Australia, described and figured by Dr. H. Woodward,[2] resembles in some respects the above species, but the glabella is more decidedly conical, and proportionally narrower. Fig. 2*a* on Dr. Woodward's plate, referred to as a telson, resembles some fragments with genal

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1 Trans. Roy. Soc. S. Australia, vol. xxix., 1905, p. 247, pl. xxv., fig. 1.

2 H. Woodward, in Foord's "Notes on the Palaeontology of Western Australia." Geol. Mag., March, 1890, p. 99, pl. iv., figs. 2, 2a, b.

spines, on our limestone samples. This is mentioned merely as a point worth consideration.

Horizon.—Upper Cambrian. Agnostus Zone. Dolodrook River.

Ptychoparia minima, sp. nov.

(Pl. LVIII., Figs. 1 and (?) 6; Pl. LIX., Fig. 22).

Note.—The subjoined description is founded principally on a cephalon without the free cheeks; but a pygidium occurring in the same limestone is also tentatively referred to the present species.

Description.—Glabella subcylindrical, comparatively long, tapering very slightly anteriorly; upper surface finely pustulate, with three distinct lateral furrows, the two posterior broad, shallow, and with a strong backward curve; neck-furrow deeply impressed, the neck-ring showing traces of a slight ridge bearing three small blunt spines directed posteriorly. Anterior border of glabella nearly semicircular, but somewhat truncated in front, broad and depressed. Palpebral lobes large, prominent, elliptical; eyes narrow, sublunate and strongly curved.

Pygidium (provisionally referred to this species), comparatively large, with about six well-defined segments. Axial lobe prominent, rounded, rapidly tapering to a point at the posterior border; narrower than in *P. thielei;* lateral lobes moderately wide, slightly rounded, and depressed in relation to the axial lobes; sutures neatly and clearly marked. Margin broader than in *P. thielei,* and with conspicuous striae parallel with the border.

Dimensions.—Length of glabella from base of neck-ring to anterior border, 6.5 mm.; greatest width of glabella, 3.25 mm. Length of palpebral lobes about 2 mm.; greatest width of neck-ring, 1 mm.

Pygidium, provisionally referred to this form, length, 7.5 mm.; greatest width, 11 mm.; greatest width of axial lobe, 2.2 mm.; width of border, 1.25 mm.

Observations.—The cranidium upon which the above specific description is based is of the same general type as that of the

preceding *P. thielei.* The glabella, however, is shorter, with only three lateral furrows; whilst the palpebral lobes are also shorter and rounder. The form of the glabella and the well developed palpebral and visula areas show its alliance with *Ptychoparia.* Two specimens occur in the present series. The characters of the pygidium, if it be referable to this species, are distinct from that of *P. thielei,* for the axis is slender and the border is definitely striated. This latter feature is also well seen in pygidia of the allied genera *Anomocare* and *Bathyuriscus.*

Affinities.—The deep and depressed border of the glabella, and the spinous processes of the neck-ring in *P. minima* may, with advantage, be compared with *Ptychoparia trilineata,* Emmons sp.[1] The latter species occurs in the Middle Cambrian of North America, but generally similar forms range throughout the system. Another interesting trilobite, showing certain characters in common with our species, is the *Conocephalites subquadratus* of Dames,[2] from the Upper Cambrian of Ta-ling (Liau-tung), China.

Horizon.—Upper Cambrian. Agnostus Zone. Dolodrook River.

Genus *Crepicephalus*, Owen, 1852.

Crepicephalus etheridgei, sp. nov.[3]

(Pl. LVIII., Fig. 8, (?) Fig. 4; Pl. LIX., Figs, 20, 21) (?).

Description.—Cranidium small, semicircular, inflated. Glabella subspherical or elongately globose, highest along the median longitudinal line; surface faintly marked with three pairs of furrows which curve forwards and outwards from either side of the middle line; frontal border depressed, sulcated and with an almost straight or slightly curved margin; neck-

1 *Atops trilineatus,* Emmons. "Taconic System," 1844, p. 20. fig. 1; pl. ii., fig. 3. *Ptychoparia trilineata,* C. D. Wallcott, "Second Contribution to the Studies on the Cambrian Faunas of N. America." Bull. U. S. Geol. Surv., No. 30, 1880, p. 203, pl. xxvii., figs. 1, 1a-c.

2 In Richthofen's "China," vol. iv., p. 12, pl. i., figs. 9, 11.

3 Named in honour of Mr. R. Etheridge, Curator of the Australian Museum who has contributed so much to our knowledge of Australian Cambrian faunas.

ring narrow, neck-furrow deeply impressed. Fixed cheeks moderately broad, subtriangular, and deeply incised at junction with the glabella; outer margin gently sloping outward posteriorly, and with a semilunar depression on the ocular margin. Surface finely tuberculate.

Pygidium broad, subquadrate, rather depressed; with the posterior border slightly produced and rounded. Axial lobe broad, and rounded on the upper surface, excepting at the terminal which has the upper surface slightly cupped; axis more than three-fourths the length of the pygidium, thus differing from that in *Dikelocephalus*, divided into five segments, all of which, except the posterior, are narrow; axial sutures wide, moderately impressed, and widely curved to almost straight; furrows of the lateral lobes at first gently sloping posteriorly, and then curving sharply backwards. Margin with a doublure, and remnants of two (?) long, divergent spines, directed backwards and outwards.

Dimensions.—

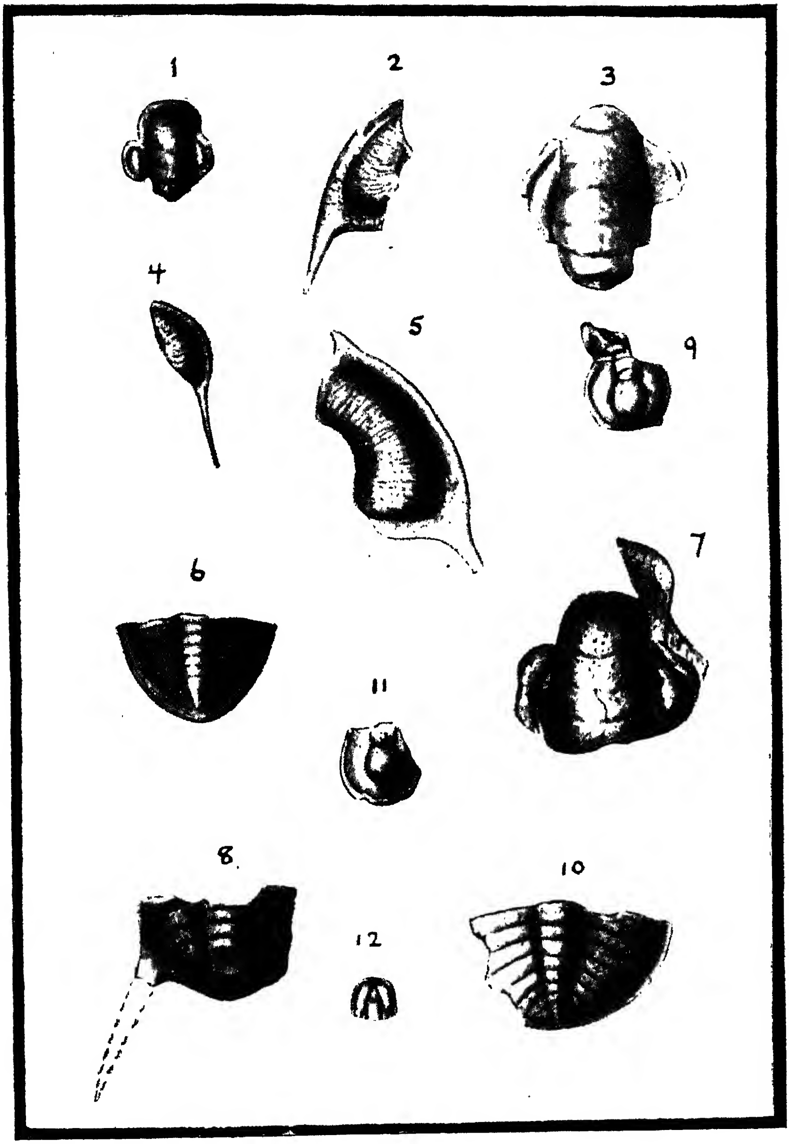
Cranidium —Length from base of neck ring to anterior border, 4.5 mm. Approximate width of cranidium, 8.5 mm. Length of glabella, 3.5 mm.

Pygidium.—Greatest width, 12 mm. Approximate length of present specimen, measured over the middle vertical line, 8 mm. Greatest width of axial lobe, 3.5 mm.

A free cheek (Pl. LVIII., Fig. 4) is also provisionally referred to this species. It is wide, more subtrigonal in shape than those of *Ptychoparia* here previously described, finely tuberculate and radiately wrinkled; anterior margin nearly straight for half the distance to the genal angle, then roundly curved to meet the long, slender, outwardly curved genal spine; external border of free cheek with a narrow rounded margin as far as the genal angle, where it merges into the genal spine.

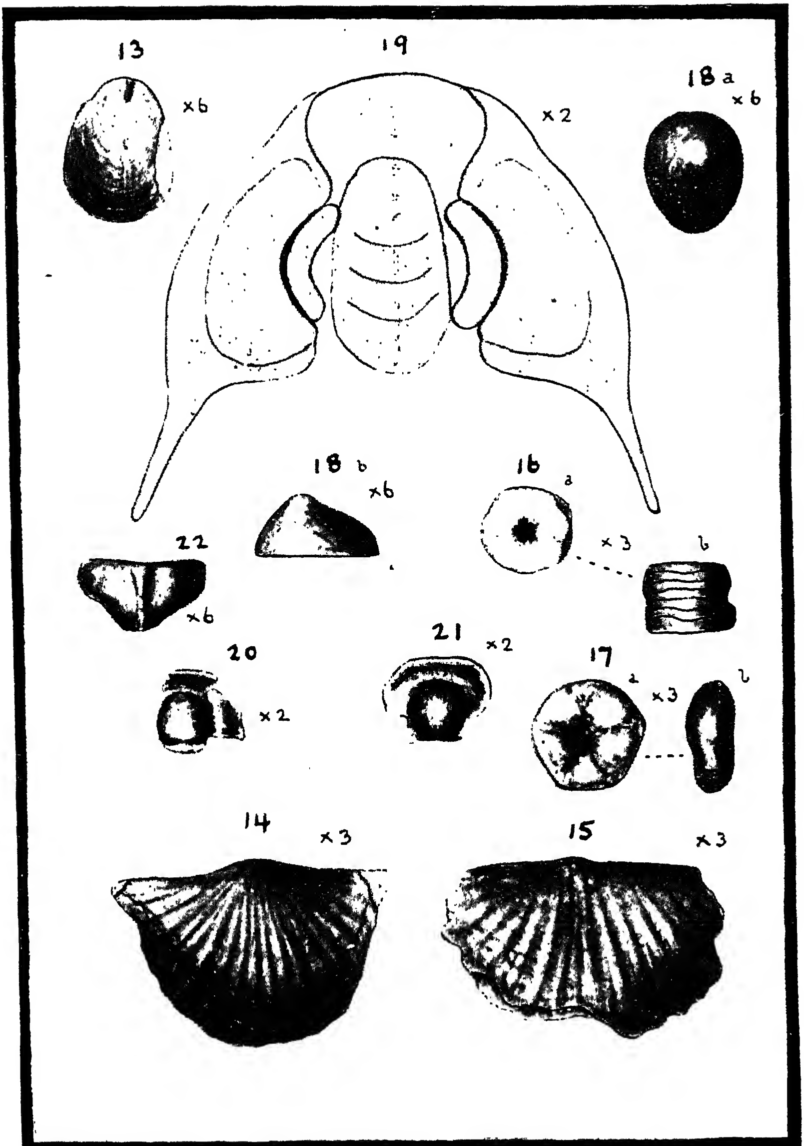
The dimensions of this free cheek are as follows:--Anterior extremity to genal angle, 5.5 mm.; length of spine, 4.75 mm.; greatest width of free cheek, about 3 mm.

Observations.—Fragmentary examples of what are here regarded as the cranidia of *Crepicephalus etheridgei* (typified by the pygidium) are not uncommon in the Dolodrook Limestone. They show the same superficial characters of a finely



F.C. ad nat. del.

Cambrian trilobites, Dolodrook R., N.E. Gippsland.



F.C. ad nat. del.

Cambrian fossils, Dolodrook R., N.E. Gippsland.

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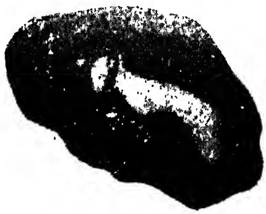
F.C., photo.

Cambrian Limestone and Brachiopods, N.E. Gippsland.

25



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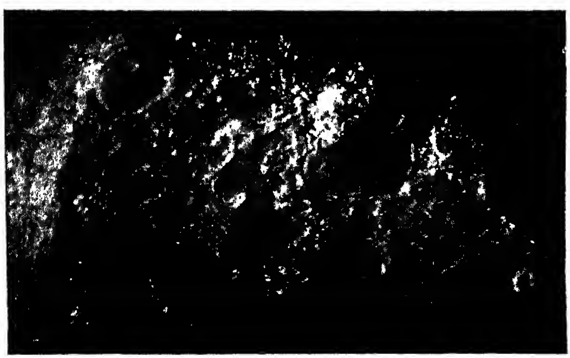

F.C., photo.

(?) Girvanella limestone, N.E. Gippsland.

tuberculate surface, as the *Crepicephalus* pygidium; and the darker-coloured fragments, as compared with those of *Ptychoparia*, exactly correspond.

Affinities.—At first sight the cranidia provisionally referred to the above genus and species, might be mistaken for a form like *Sphaerophthalmus alatus*, Boeck sp.[1] (= *Olenus humilis*, Phillips); but there is no deeply marked basal furrow on the glabella corresponding to forms of that genus. R. P. Whitfield has described and figured the cranidium of a species of *Crepicephalus*[2] which shows all the fundamental characters of the form here dealt with. He also gives a profile view of the same form, and its resemblance to ours is even more striking than the superficial view. The glabella of our trilobite is more decidedly globose than in Whitfield's species, which, although highly convex, is broadly conical; but in both forms the anterior border and the deep neck furrow are similar in character. The fixed cheeks, moreover, are larger in our species. *Crepicephalus onustus*, Whitfield, occurs in the Potsdam Sandstone (Upper Cambrian) of Wisconsin, U.S.A.

The pygidium here regarded as the holotype of the above species shows a remarkable resemblance to that figured as *Crepicephalus liliana*, Walcott, from the Middle Cambrian of Nevada, U.S.A.[3] That species is of slender proportions, and the tail spines are less divergent than is indicated in our specimen. The two forms agree in the rounded shape and almost even width of the axial lobe, and in having a deep incision between the last and penultimate suture-line of the anterior region.

This genus occurs throughout the Upper Cambrian in North America. The genotype, according to C. D. Walcott[4] is *Crepicephalus iowensis*, Owen sp.[5] It is a characteristic fossil of

1 *Trilobites alatus*, Boeck, 1838, Goea Norwegica, I., p. 143, Ol. (Sph.) humilis, Phillips 1848, Mem. Geol. Surv. Gt. Brit., vol. ii., pt. 1, p. 55, woodcuts figs. 4, 5, 6.

2 *C. onustus*, Whitfield. Geol. of Wisconsin Survey of 1873-9, vol. iv., 1882, p. 182, pl. i., figs. 22. 23.

3 "Second Contr. to the Studies on the Cambrian Faunas of N. America." Bull. U.S. Geol. Surv., No. 30, p. 207, pl. xxviii., figs. 3, 9a-c.

4 Op. supra cit., p. 206.

5 *Dikelocephalus* (?) *iowensis*, Owen. Geol. Rep. of Wisconsin, Iowa and Minnesota, 1852, p. 575, pl. i., fig. 4. *Ptychoparia (Crepicephalus) iowensis*, Owen sp., C. D. Walcott, Bull. U.S. Geol. Surv., 1884, No. 10, p. 36, pl. vi., fig. 2, 2a.

the Potsdam Sandstone of the Upper Mississippi, U.S.A. *C. iowensis*, it may be remarked, shows similar features to the Australian species; chiefly differing in the broad, flattened bases of the tail spines. The remnants of the latter seen in our example indicate a more slender type of appendage. In all but the pygidial spines *Crepicephalus* agrees with *Ptychoparia*, so that the free cheek above referred to, whilst presenting some of the features of *Ptychoparia*, may reasonably be supposed to belong to the present species.

Horizon.—Upper Cambrian. Agnostus Zone. Dolodrook River.

EXPLANATION OF PLATES LXIII.—LXI.

Plate LVIII.

Fig 1.—*Ptychoparia minima*, sp. nov. Portion of cephalon, without free cheeks. Holotype.

Fig. 2.—*Ptychoparia thielei*, sp. nov. Free cheek and spine. Paratype.

Fig. 3.—*Ptychoparia thielei*, sp. nov. Portion of cephalon without free cheeks. Paratype.

Fig. 4.—(?) *Crepicephalus etheridgei*, sp. nov. A free cheek with spine.

Fig. 5.—*Ptychoparia thielei*, sp. nov. Free cheek of a large example. Cotype.

Fig. 6.—(?) *Ptychoparia minima*, sp. nov. Pygidium.

Fig. 7.—*Ptychoparia thielei*, sp. nov. Part of cephalon without free cheeks. Cotype. (On the left side of the glabella and next the palpebral lobe is a (?) *Linguella*).

Fig. 8.—*Crepicephalus etheridgei*, sp. nov. Pygidium. Holotype.

Fig. 9.—*Agnostus australiensis*, sp. nov. Pygidium, and fragment of thoracic region (crushed). Cotype.

Fig. 10.—*Ptychoparia thielei*, sp. nov. Pygidium. Cotype.

Fig. 11.—*Agnostus australiensis*, sp. nov. Pygidium. Paratype.

Fig. 12.—*Agnostus australiensis*, sp. nov. Head of small specimen. Cotype.

All figures on the plate magnified twice.

PLATE LIX.

Fig. 13.—(?) *Lingulella*, sp. A fragmentary valve adhering to the glabella of *Ptychoparia thielei*. × 6.

Fig. 14.—Pedicle valve of *Orthis* (*Plectorthis*) *platystrophioides*, sp. nov. × 3.

Fig. 15.—Brachial valve of *Orthis* (*Plectorthis*) *platystrophioides*, sp. nov. × 3.

Fig. 16.—Crinoid columnars, indet.: *a*, articular face: *b*, side view. × 3.

Fig. 17.—Crinoid columnar, indet. Probably a nodal joint: *a*, articular face; *b*, edge view. × 3.

Fig. 18.—*Scenella tenuistriata*, sp. nov.; *a*, apical aspect; *b*, side view. × 6.

Fig. 19.—Restoration of the cephalon of *Ptychoparia thielei*, sp. nov. × 2.

Fig. 20.—(?) *Crepicephalus etheridgei*, sp. nov. Portion of a cranidium, showing the rounded form of the glabella. × 2.

Fig. 21.—(?) *C. etheridgei*, sp. nov. A cranidium, with tuberculate surface. × 2.

Fig. 22.—*Ptychoparia minima*, sp. nov. Neck ring, showing the spinose character of the median ridge. × 6.

PLATE LX.

Fig. 23.—Photomicrograph of a section of the trilobite limestone (Dolodrook River). × 14.

Fig. 24.—Four examples of *Orthis* (*Plectorthis*) *platystrophioides*, sp. nov. The upper specimen is a brachial valve; the lower, pedicle valves. Roan Horse Gully. About natural size.

PLATE LXI.

Fig. 25.—A section through one of the (?) *Girvanella* pellets, showing nucleus formed by a crinoid ossicle. Roan Horse Gully. × 7.

Fig. 26.—Photograph of surface of nodular or (?) *Girvanella* limestone. Roan Horse Gully. About natural size.

CORRIGENDA AND ADDENDUM.

For paper, "A Study of the Batesford Limestone," in this Journal, Vol. XXII. (N.S.), Pt. II., 1909.

P. 263, line 16 from top, for "N.E." read "N.W."

P. 297, line 8 from top, for "Leptocyclines" read "Lepidocyclines."

P. 310, line 12 from top, for "onomata" read "onamata."

P. 510, footnote 3, for "Vol. XXX." read "Vol. XIII."

P. 305, between lines 18 and 19, insert "Echinoneus dennanti, T. S. Hall."

[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. II., 1911.]

ART. XXVII.—*The Magnetic Properties of Stalloy.*

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(With Plates LXII.-LXV.).

[Read November 10th, 1910].

(Communicated by Professor T. R. Lyle).

In the following paper are given the results of an investigation into the magnetic properties of the iron alloy called "Stalloy." Particular attention has been given to "Stalloy" by many investigators on account of the claims made by its inventor (Hadfield) with regard to its magnetic properties. The special feature of this alloy is its high specific electric resistance and high permeability. The specific resistance being about four times that of the best transformer iron, the eddy-current loss for a given thickness of sheet would be greatly reduced, so that lamination need not be carried out to anything like the extent necessary with ordinary iron, and the question of insulation of laminae becomes less troublesome. It is more expensive than ordinary iron, but the increased expense is compensated by a reduction in size of the transformers etc., constructed of it, an increase in output, and greatly improved efficiency.

The special chemical feature of "Stalloy" is that it contains about 3.4 per cent. Silicon. The value of this alloy is emphasised in a paper by Epstein[1], where several tests of its properties are given.

Several investigations have been made by other experimenters by direct current methods, which agree fairly well together.

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1 Epstein. J.I.E.E., vol. xxxvi., 1907. Professor Turner gives the analysis as follows: Carbon .03, Silicon 3.4, Sulphur .04, Phosphorus .01, Manganese .32, Iron 96.20 per cent.

The most interesting of these are given by Wilson and others[1], Watson,[2] and the manufacturers, Sankey and Sons.[3]

Some interesting experiments on an alloy very closely allied to "Stalloy" are given by Barrett, Brown, and Hadfield[4], and by Baker.[5]

The object of the present research was to investigate the magnetic properties of "Stalloy," not only with direct current, but also with alternating currents of varying frequencies. quencies.

The experiments have been divided into three divisions:—

(1) Statical tests.

(2) Effect of variation of frequency on magnetic hysteresis.

(3) Effect of annealing upon each of the above.

The usual statical experiments were made for inductions extending up to about 14,000. From these results were calculated the hysteresis losses and Steinmetz coefficients using as exponent in the usual formula the value 1.6 which was found to be approximately correct for this substance. The determination of these coefficients is important, as from their values we are able to separate the hysteresis from the total loss in each of the alternating experiments.

The tests were made upon two rings as nearly alike as possible, one annealed, the other unannealed.

The alternate current experiments were divided into three series, of periods .07, .035, .02 respectively. In each of these the period and wave form of the magnetizing current were kept as nearly as possible constant as the induction density increased. The expressions for the amplitude and phase both of H and B are given in the tables which follow.

From these expressions, for each pair of associated waves of H and B was calculated the total loss per c.c. per cycle (I).

This was found to follow fairly well a formula proposed by Lyle[3] for total loss in iron, namely:—

$$I = (\alpha + \beta n)\mathfrak{B}^{x}$$

1 Wilson, Winson and O'Dell. Proc. Roy. Soc. Lond., 1908, vol. lxxx,

2 Watson. Electrician, vol. lx., p. 4.

3 Article "Stalloy." Electrician, vol. lviii., p. 692.

4 Barrett, Brown and Handfield. J.I.E.E., 1902.

5 Baker. J.I.E.E., December, 1904.

where α, β and x are constants for the material, n the frequency and $\mathfrak{B}$ is the "effective induction," a quantity of great importance in the calculation of the eddy current loss (E), as will be explained later.

The method employed was similar to that described by Professor Lyle[1]. By means of his wave-tracer[2] the wave forms of the magnetizing current and the resultant magnetic flux pulsating in the iron can be accurately determined. The full wave being obtained, fifteen ordinates per half wave were taken, from which, without plotting, the first, third and fifth harmonics composing the waves can be calculated. Two methods of harmonic analysis were used (1) for approximately sinusoidal waves, that devised by Lyle[3], (2) for waves into which harmonics higher than the fifth entered considerably, that of S. P. Thompson[4].

The wave forms having been analysed, the results were reduced to absolute measure by the application of proper factors[4]. The magnetizing force and induction were thereby obtained in the form—

$$H = H_1[\sin\omega t + h_3\sin 3(\omega t - \phi_3) + h_5\sin 5(\omega t - \phi_5) + \ldots\ldots\ldots]$$
$$B = B_1[\sin(\omega t - \theta) + b_3\sin 3(\omega t - \theta_3) + b_5\sin 5(\omega t - \theta_5) + \ldots\ldots]$$

In general, harmonics higher than the fifth were neglected and are not given in the tables. In calculating the total losses, however, these upper harmonics were included.

From these equations the value of the total loss per c.c. per cycle—

$$I = \frac{1}{4\pi}\int H dB$$
$$= \frac{H_1 B_1}{4}[\sin\theta + 3h_3 b_3 \sin 3(\theta_3 - \phi_3) + 5h_5 b_5 \sin 5(\theta_5 - \phi_5)]$$

is determined.

The amount of eddy-current loss per c.c. per cycle (E) was calculated from the approximate formula given by Searle and Bedford[5].

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1 T. R. Lyle. Phil. Mag., 1905, vol. ix.
2 T. R. Lyle. Phil. Mag., 1903, vol. vi.
3 T. R. Lyle. Phil. Mag., 1906, vol. xi., also Proc. Roy. Soc. Victoria, vol. xvii.
4 S. P. Thompson. Electrician, 1905.
5 Searle and Bedford. Phil. Trans., 1902, App.

$$\frac{dX}{dt} = \frac{x^2}{12\rho}\left(\frac{db}{dt}\right)^2$$

Where X is the space average of eddy-current loss.

x the thickness,

ρ the specific resistance,

μ the permeability being assumed constant.

From this the eddy-current loss per c.c. per cycle may be reduced to the form[5].

$$E = \frac{\pi^2 x^2}{6\rho T}\mathfrak{B}^2$$

$$\text{where } \mathfrak{B} = B_1[1 + 9b_3^2 + 25b_5^2 + \ldots\ldots]^{\frac{1}{2}}$$

$$= \frac{\sqrt{2}}{\omega}\text{R.M.S.}\left(\frac{dB}{dt}\right).$$

The statical hysteresis (U) was determined by Ewing and Klaasen's ballistic method, and from the results the Steinmetz coefficient σ obtained was plotted against the maximum induction by the use of the formula—

$$U = \sigma B^{1.6}_{\text{Max.}}$$

In order to determine the value of U for alternating currents, it was assumed that it was equal to that obtained by the statical method for maximum induction equal to the maximum value (B_0) of B. From the above mentioned graph and formula U has been calculated for all inductions.

Having obtained all these quantities, the valnes of I-U-E, called by Fleming the 'kinetic hysteresis,' were calculated. These as well as I, U, E, have been given for each experiment.

The rings were prepared from the same sheet and were made as nearly alike as possible. A thin sheet of waxed paper separated each pair of discs and the wire used in the winding was taken from the same coil. After the laminae were well cleaned the mean thickness was determined by the specific gravity method.

The specific resistance was determined by the "drop of potential" method against a standard .1 ohm by means of a Wolff's potentiometer. Experiments were made on two samples, one of length about 80 cms. cut from the sheet, and another

from a thin annulus cut from one of the actual rings used. The results differed by less than .1 per cent and agreed fairly well with the results of other experimenters.

The details of the coils are:—

	Annealed.	Unannealed.
No. of laminae - - - -	6	6
Internal diameter - - -	6.927 cms.	6.927 cms.
External „ - - -	9.549 cms.	9.557 cms.
Mean thickness (x) - -	.0757 cm.	.0739 cm.
Area of cross section - -	.5953 sq cm.	.5830 sq. cm.
Length of magnetic circuit -	25.87 cms.	25.90 cms.
Primary turns - - -	135	135
Secondary turns - - -	10 or 50	10 or 50
Specific resistance at 19° C -	50320	50440
Specific gravity at 19° C -	7.58	7.582

The reduction factor of the galvanometer used in the secondary circuit was obtained by passing the current from a cadmium cell through a megohm and the galvanometer in series.

All the resistances used were carefully tested during the course of the experiments, as were also the two standard M coils which were used to determine the absolute value of the magnetizing force.

The symbols used in the accompanying tables are as follow:—

$$T = \text{period} = 2\pi/\omega = \cdot 07,\ \cdot 035,\ \cdot 02 \text{ approx.}$$
$$H = H_1[\sin\omega t + h_3\sin 3(\omega t - \phi_3) + h_5 \sin 5(\omega t - \phi_5) + \ldots\ldots\ldots]$$
$$B = B_1[\sin(\omega t - \theta) + b_3 \sin 3(\omega t - \theta - \psi_3) + b_5 \sin 5(\omega t - \theta - \psi_5) + \ldots]$$
$$\mu_0 = B_1/H_1 \quad \mu = B_0/H_0.$$
$$U = \sigma B_0^{1.6} \quad \mathfrak{B} = \frac{\sqrt{2}}{\omega}\text{R.M.S.}\left(\frac{dB}{dt}\right)$$

I = Total loss per c.c. per cycle.

U = Statical hysteresis loss per cycle.

E = Eddy current loss per cycle.

I—U—E = Kinetic hysteresis per cycle.

In Tables I., II., III., are given the analytical results reduced from the series of experiments on the annealed ring, while

Table I. Annealed Stalloy Speed ·072 (q.p.)

No	T	H_1	$-h_3$	ϕ_3	h_5	ϕ_5	B_1	θ	b_3	ψ_3	b_5	ψ_5	μ_0	B_{max}	H_{max}	μ	$\mathfrak{B}$	I	U	E	I-U-E
1	·0727	643	·0337	5·01°	·0078	21·17°	1047	23·37°	·091	24·7	023	29·23°	1628	1029	·655	1571	1091	65·3	69·0	3·1	—
2	0730	·915	·0389	2·91	·0027	35·47	2574	34·2	·133	16·2	042	21 13	2812	2426	·936	2590	2823	326·0	298 0	20·4	7·6
3	0732	1·334	·0364	7·25	·0025	26·42	5338	37·14	176	9·85	·0552	12 81	3999	4857	1·379	3521	6211	1047	902·2	96·3	48·5
4	·0730	1·566	·0363	8·63	0073	33·90	6487	35·66	184	8·53	·0612	10·39	4141	5771	1·611	3529	7874	1437	1204	151·0	82·0
5	·0729	1·770	·0408	9·58	·0094	34·62	7275	33·99	·188	7·42	·0647	9·80	4109	6422	1·848	3474	8678	1729	1437	193·2	98·8
6	·0721	2638	·0671	2·91	·0123	10·09	9762	28·78	·203	5·99	·0757	7·65	3700	8468	2·780	3046	12000	2861	2312	374·1	174·9
7	·0719	4·434	·0765	1·13	·0218	6·36	12053	22·85	215	4·85	·0859	6·16	2818	10330	4·682	2206	15240	4625	3257	603·7	764
8	·0722	7·988	·0798	−·32	·0398	1·58	14731	16·02	·220	3·16	·0945	5·07	1844	12447	8·385	1485	18980	7341	4502	933·0	1906
9	·0721	9 796	·0710	−7·8	·0410	2·03	15380	14·78	·227	2·87	·0975	4·82	1597	12941	10·20	1269	20290	8594	4848	1082	2664
10	·0727	12·566	·0728	−6·49	−·0400	35·30	16123	14·4	·234	2·66	·1016	4·27	1283	13421	13·17	1021	21310	10600	5158	1169	4273
11	·0736	17·653	·0774	−9·84	−·0405	33·67	17094	11·74	241	2·05	·1047	3·79	968	14168	18·53	764	22910	13470	5678	1334	6478
12	·0749	29·778	·0822	−12·36	−·0506	30·34	18270	10·77	·250	1·62	·1158	3·00	614	15068	31·60	453	25160	21160	6437	1580	13143

Table II Annealed Stalloy Speed 035 (q.p)

No	T	H_1	$-h_3$	ϕ_3	h_5	ϕ_5	B_1	θ	b_3	ψ_3	b_5	ψ_5	μ_0	B_{max}	H_{max}	μ	$\mathfrak{B}$	I	U	E	I-U-E
1	0355	·611	·0293	6·28°	·0057	33·95°	345·9	10·02°	·0325	29·82°	·0091	41·16°	566	343	·622	551	348	9·1	13·7	64	—
2	·0356	·925	·0337	7·59	·0041	22·64	1848	32·68	1043	20·12	·0278	25·12	1998	1740	956	1820	1953	227·6	173	20·0	34·6
3	·0350	1·192	·0335	11·61	·0029	17·69	3817	40·30	·1318	14·30	·0334	18·23	3202	3436	1 229	2793	4149	723	518	91 9	113·1
4	·0350	1·407	·0372	12·97	·0045	17 70	5325	41·50	14·95	11·90	0369	15 41	3783	4893	1·420	3446	5917	1214	915	187·3	111 7
5	·0350	1·829	·0371	15·76	·0069	17·45	7312	38·02	·1635	8·91	·0438	12·19	3997	6396	1·890	3384	8301	2000	1429	367·7	203 3
6	·0352	2·272	·0357	12·24	0079	15·69	8494	34·90	·1800	7·75	·0506	10 48	3739	7529	2·342	3210	9888	2619	1888	519·5	226·5
7	·0354	3·199	·0595	7·35	0147	14·43	10650	29·82	·1880	6·16	·0636	9 13	3329	9288	3·365	2762	12690	3984	2705	850·7	428
8	·0355	6·078	·0702	1·38	0205	6·46	13586	20·56	·2060	5·21	·0809	7·68	2235	11580	6·260	1803	16890	6533	3945	1503	1085

Table III Annealed Stalloy Speed ·020 (q.p)

No.	T	H_1	$-h_3$	ϕ_3	h_5	ϕ_5	B_1	θ	b_3	ψ_3	b_5	ψ_5	μ_0	B_{max}	H_{max}	μ	$\mathfrak{B}$	I	U	E	I-U-E
1	0202	·639	0377	16·80°	0082	19 13°	939	25·67°	046	33·36°	·0078	38·24°	1471	953	660	1445	949	64·4	60·4	8·4	—
2	0205	977	0321	18·18	0066	22·79	2514	40·68	·083	22 88	0132	29·54	2573	2489	·994	2506	2607	396·8	312	62 1	22 7
3	0206	1·249	0340	22·56	·0071	18 91	4465	47·24	114	15·90	·0163	21·39	3575	4299	1·335	3221	4733	1005	743	203 2	58·8
4	0205	1·556	0312	22 36	0049	16·16	6019	45·15	121	12·03	0185	17·34	3870	5602	1·586	3516	6424	1632	1146	375·9	106·0
5	·0206	1·850	0318	21·30	·0017	11·99	7059	42·55	132	10·61	0189	16·56	3841	6540	1·891	3460	7619	2198	1489	532·1	176·9
6	0209	2·198	0324	20·91	·0058	13·59	8071	40·16	141	9 33	0273	15·19	3671	7244	2·212	3248	8851	2800	1770	702·6	327·4
7	0211	4·423	0751	10·59	0143	22 27	12104	27 74	163	6·66	·0487	10·91	2736	9846	4·66	2112	13790	5625	2995	1685	945·0
8	0217	7·768	0767	5·11	·0232	31 84	14401	20·85	192	4·16	·0687	7·88	1853	12333	8·28	1492	17353	8760	4443	2598	1719

Table IV. Unannealed Stalloy. Speed ·072 (q.p.)

No.	T	H_1	$-h_3$	ϕ_3	h_5	ϕ_5	B_1	θ	b_3	ψ_3	b_5	ψ_5	μ_0	B_{max}	H_{max}	μ	𝔅	I	U	E	I-U-E
1	·0713	·5340	·0303	7·87	·0042	28·81	724	26·85	·0956	21·03	·0278	27·48	1357	710	·547	1296	760	42·94	31	1·5	10·4
2	·0715	8175	·0319	4·10	·0035	12·57	2023	33·04	·1340	16·78	·0404	19·88	2475	1910	·843	2266	2218	222·8	204	12·3	6·5
3	·0714	1·265	·0303	8·43	·0040	11·30	3760	31·55	·1701	10·00	·0564	12·55	2972	3388	1·296	2613	4351	604·0	531	47·5	25·5
4	·0722	1·467	0281	9·11	·0028	12·50	4425	30·66	·1692	8·39	·0577	10·64	3016	3591	1·496	2640	5128	815·2	663	65·2	87 0
5	·0714	1·656	·0318	7·47	·0010	8·80	5041	29·38	·1742	8·03	·0626	9·32	3044	4477	1·696	2635	5902	989·6	808	87·4	94·2
6	0713	4·218	·0488	1·46	-·0154	9·85	9166	21·12	·1931	4·18	·0769	5·82	2173	8080	4·345	1860	11180	3175	2221	314·2	639·8
7	0709	8·546	-·0533	54 90	-·0228	2 37	12328	13·22	·1924	3·36	·0786	4·05	1442	10613	8·845	1196	15030	5379	3480	570·7	1328
8	·0729	10·40	-·0516	55·08	-·0236	0 02	13294	11·56	·2047	2·47	·0825	3·93	1278	11177	10·76	1007	16533	6337	3942	671·0	1724
9	·0729	17·71	-·0524	51·10	-·0279	-1·48	15069	8·11	·2222	2·36	·0838	3·82	850·8	12827	18·12	709	19178	8235	5063	903·0	2195
10	·0734	21·00	-·0518	51·40	-·0276	-1·81	15770	7·12	·2264	2·33	·0948	3·70	750·7	13248	21·62	613	20480	9360	5383	1023	3206
11	0736	25·90	-·0748	56·05	-·0303	-7·92	16617		·2401		·1126		641·4	13845	27·20	509	22510	10862	5909	1233	3720

Table V. Unannealed Stalloy. Speed ·035 (q.p.)

Nº	T	H_1	$-h_3$	ϕ_3	h_5	ϕ_5	B_1	θ	b_3	ψ_3	b_5	ψ_5	μ_0	B_{max}	H_{max}	μ	$\mathfrak{B}$	I	U	E	I-U-E
1	·0355	·751	·0302	5°·67	·0018	3°·52	1044	24°·28	·0788	25°·34	·0189	32°·85	1391	1034	·773	1347	1077	81·56	64·4	5·9	10·3
2	·0354	1·047	·0285	7·43	·0047	6·16	2071	31·98	·0940	18·79	·0277	24·54	1977	1991	1·075	1852	2171	284·4	234	23·8	26·2
3	·0357	1·498	·0270	9·92	·0039	25·15	4127	35·68	·1436	12·58	·0398	16·06	2754	3738	1·530	2444	4568	886·2	617	104·6	165·1
4	·0360	1·709	·0385	12·00	·0025	23·49	4816	34·20	·1600	11·88	·0460	14·25	2819	4391	1·760	2499	5454	1115	785	147·7	182·3
5	·0365	1·861	·0269	8·83	·0013	20·19	5393	32·84	·1636	10·47	·0514	12·84	2898	4892	1·951	2509	6155	1326	915	185·9	225·0
6	·0365	2·296	·0282	7·52	·0039	13·51	6457	29·87	·1727	8·42	·0599	11·45	2812	5732	2·424	2362	7522	1793	1232	277·8	283·2
7	·0360	2·962	·0235	7·21	·0038	1·72	7568	26·87	·1842	7·88	·0675	9·27	2555	6627	3·240	2191	9015	2468	1624	403·7	440·3

Table VI. Unannealed Stalloy. Speed ·021 (q.p)

Nº	T	H	$-h_3$	ϕ_3	h_5	ϕ_5	B_1	θ	b_3	ψ_3	b_5	ψ_5	μ_0	B_{max}	H_{max}	μ	$\mathfrak{B}$	I	U	E	I-U-E
1	·0209	·781	·0286	7°·30	·0008	8°·10	1262	32°·32	·0795	25°·64	·0074	31°·38	1616	1261	·801	1542	1298	128·4	92·1	14·4	21·9
2	·0209	1·072	·0407	10·25	·0005	11·79	2372	39·24	·1063	20·60	·0193	26·31	2213	2325	1·102	2067	2500	473·5	291·2	53·6	128·9
3	·0208	1·500	·0269	10·78	·0024	12·38	3965	41·04	·1324	14·69	·0256	19·93	2642	3872	1·525	2486	4298	985·2	649·0	159·2	181·0
4	·0212	1·699	·0249	15·07	·0038	13·55	4686	40·03	·1318	12·91	·0306	17·87	2759	4363	1·726	2475	5090	1262	779·6	219·1	263·3
5	·0215	1·897	·0222	13·34	·0045	14·06	5231	37·60	·1395	11·96	·0362	15·94	2758	4816	1·928	2444	5749	1495	923·8	275·1	296·1
6	·0216	2·289	·0222	11·39	·0065	15·03	6319	34·50	·1530	9·96	·0424	13·90	2763	5726	2·398	2338	7084	2015	1231	415·4	368·6
7	·0219	4·968	·0474	5·99	·0134	18·81	9867	23·68	·1750	7·21	·0610	10·68	1986	8626	5·050	1678	11537	4666	2500	1090	1076

Tables IV., V., VI., give the corresponding results for the unannealed ring.

In each set a space is left in the rows below which the influence of the higher harmonics begin to be noticeable. Generally the sign of these higher harmonics is negative in the magnetizing force, and in the induction always positive. S. P. Thompson's method of analysis was used for these more distorted waves and the inclusion of the higher harmonics considerably modified the total losses.

Above the space in the rows, the readings may be taken as belonging to approximately sinusoidal waves. In the graphs all the chief characteristics of the induction waves are plotted against the amplitude of their first harmonic (B_1).

The results of the statical experiments show several interesting features. The hysteresis constant has its maximum value about .0015 which is about the same as Epstein's value. On plotting it against the induction a smooth curve was obtained which rises from the origin to a maximum value at an induction of 3000 (the value of σ being .00122), it then decreases to a minimum at 4000, after which there is a steady rise which continues as far as the experiments go. This curve is similar in shape to that obtained when using ordinary iron.[1]

"Stalloy" needs careful handling especially in the unannealed state in order to obtain symmetrical results. When the magnetizing current is gradually increased and reversals are frequently the hysteresis loops are symmetrical and the Steinmetz coefficient when plotted against the maximum induction gives a smooth graph. But if, after working at high densities, an experiment is made with a small magnetizing force the loop will be found to be unsymmetrical and the corresponding value of σ will lie outside the previously obtained σ graph. This has also been drawn attention to by Wilson. In the unannealed state therefore "Stalloy" seems to be magnetically unstable so that the previous history of the material has a very marked effect upon its subsequent behaviour. The annealed "Stalloy" showed similar results but these were very little more noticeable than those obtained for ordinary iron.

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1 T. R. Lyle. Loc. cit.

The other chief results of annealing are to increase the permeability and to lower the hysteresis loss. The values of the permeability μ did not rise to nearly the values obtained by other observers. For unannealed "Stalloy" the maximum is 2660 at an induction of about 4000 and in the annealed rises to 3500 at an induction of about 6000.

Table VII. Statical Results.

(a) Unannealed Stalloy.

No.	H_{max}	B_{max}	μ	U
1	·6366	743 2	1167	32 90
2	·9879	2301	2329	287 4
3	1·257	3338	2655	523·0
4	1·500	3987	2658	677 9
5	1·801	4734	2629	928·7
6	1·992	5161	2591	1057
7	3·189	6805	2134	1668
8	6 632	9404	1418	3061
9	11·747	11458	976 4	4172
10	19 497	12532	642 8	4609

(b) Annealed Stalloy.

No.	H_{max}	B_{max}	μ	U
1	·6411	6844	1068	32·17
2	·9464	2262	2390	266·8
3	1·276	4152	3254	699 7
4	1·756	6074	3459	1318
5	1·977	6762	3420	1564
6	6·320	11645	1842	3966
7	16·035	13952	870	5600

The more important results of the experiments for alternating currents will be readily seen by reference to the accompanying figures while their more accurate details are given in Tables I. to VI.

In making comparisons between "Stalloy" and ordinary iron the results obtained by Professor Lyle for good samples of transformer iron have been assumed.

In Figs. 1, 2a, 2b, the more important characteristics of the induction waves which are set out in Tables I. and IV. are plotted against the amplitudes of the first harmonics of these waves.

The curves obtained for "Stalloy" are typical in general appearance of those obtained for iron and, although plotted here for only the lowest frequency, will be found similar in appearance for all the induction waves, provided the periods are constant throughout a series of experiments and are produced by currents of similar wave forms.

The characteristics μ_0 and θ fall in all cases to low values as the values of B_1 become small and probably vanish with B_1. The rise of θ in the region of low densities is steeper for annealed iron than for annealed "Stalloy," the appearance of the graph for iron being somewhat like that drawn here for the unannealed "Stalloy." There is this important difference, namely, that for iron, θ frequently rises to maximum of 52° whereas for "Stalloy" the maximum obtained for the same frequency was 47°.

The effect of annealing upon θ is to increase its magnitude for all inductions over about 2000. It will be noticed in the accompanying graph that the maximum value of θ increases on annealing from 33° to 38°. After attaining a maximum value for θ the graph assumes a steady downward gradient, which is practically constant for both annealed and unannealed samples. Along this gradient there is approximately a constant difference in value of θ of about 8° for all values of the above inductions. For ordinary working inductions therefore 8° may be taken as the increase effect produced upon θ by annealing.

A difference in the appearance of the permeability curve is to be noted. For iron this curve takes an almost parabolic form, having its axis vertical and its apex at an induction of about 10,000 the maximum value of μ_0 rising only a little above 3,000 generally.

Annealed "Stalloy" has a maximum permeability of 4140 which is attained at an induction of 6500, while the unannealed ring gives a maximum value of about 3100 at an induction of

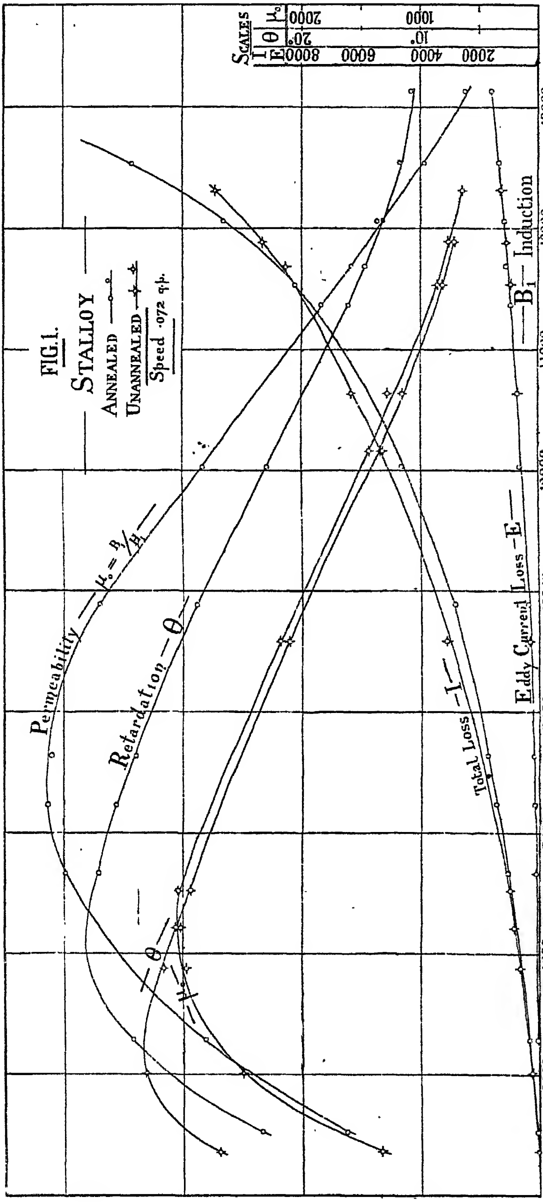
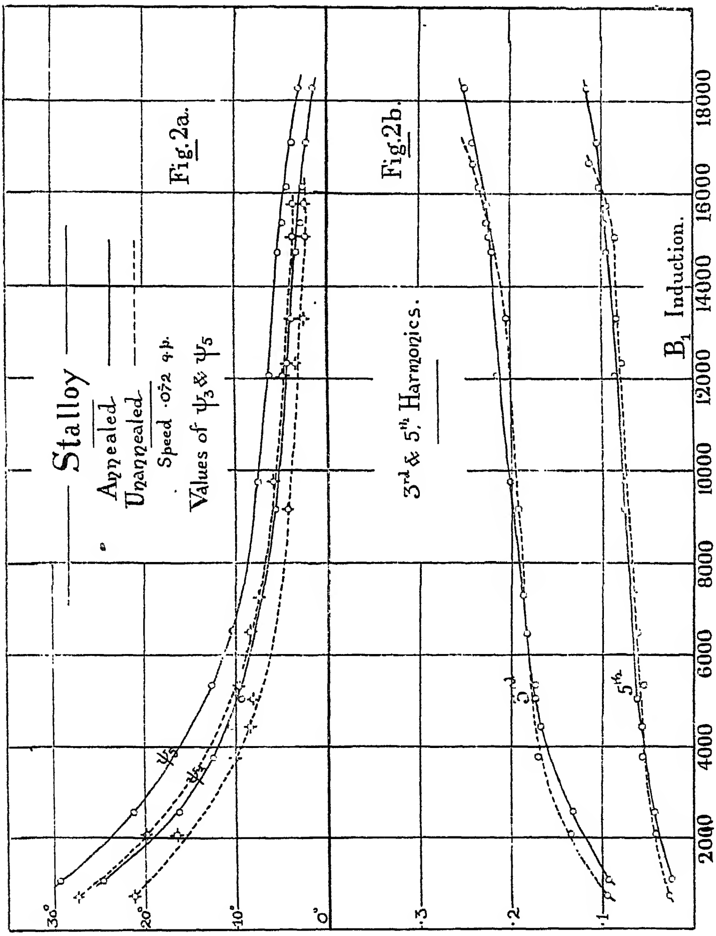


FIG. 1.
STALLOY
ANNEALED
UNANNEALED
Speed ·072 q.p.
SCALES
I
θ
μ₀
E
2000
1000
20°
10°
8000
6000
4000
2000
Permeability — $\mu_o = B_1/H$ —
Retardation — θ —
— θ —
— I —
— I —
Total Loss
Eddy Current Loss — E —
— B_1 — Induction
2000
4000
6000
8000
10000
12000
14000
16000
18000


Stalloy
Annealed
Unannealed
Speed ·072 q.p.
Values of ψ3 & ψ5
Fig. 2a.
Fig. 2b.
3rd & 5th Harmonics.
B1 Induction.
30°
20°
10°
0°
·3
·2
·1
2000
4000
6000
8000
10000
12000
14000
16000
18000

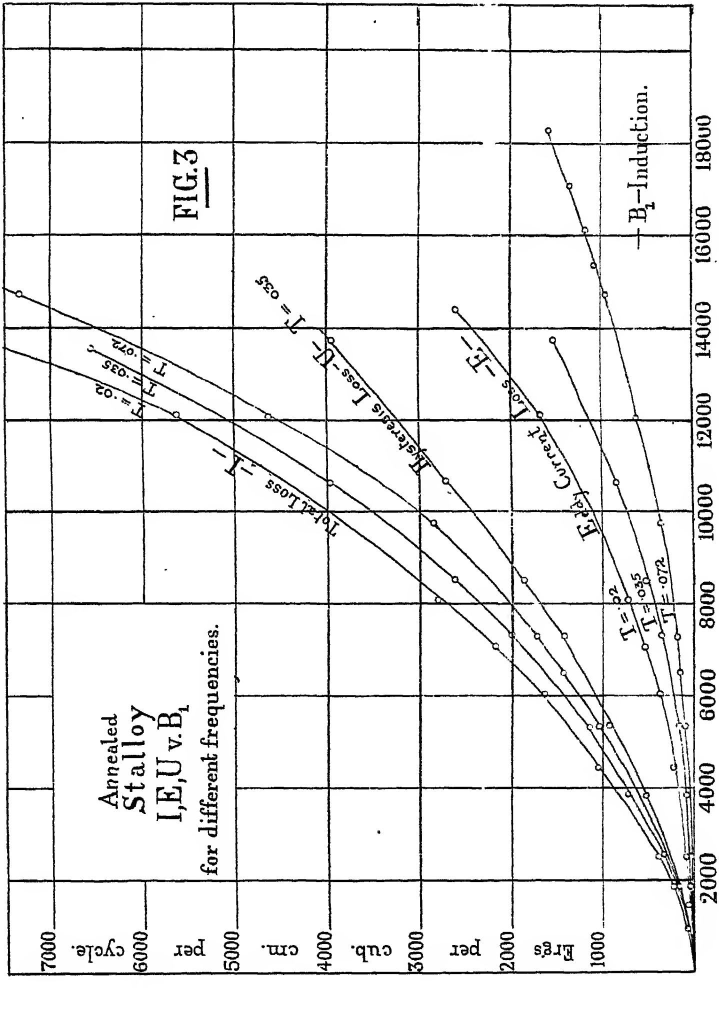


FIG.3
Annealed
Stalloy
I,E,U v. B_1
for different frequencies.
Total Loss -I-
T = ·02
T = ·035
T = ·072
Hysteresis Loss -U- T = ·035
Eddy Current Loss -E-
T = ·02
T = ·035
T = ·072
— B_1—Induction.
2000
4000
6000
8000
10000
12000
14000
16000
18000
Ergs per cub. cm. per cycle.
1000
2000
3000
4000
5000
6000
7000

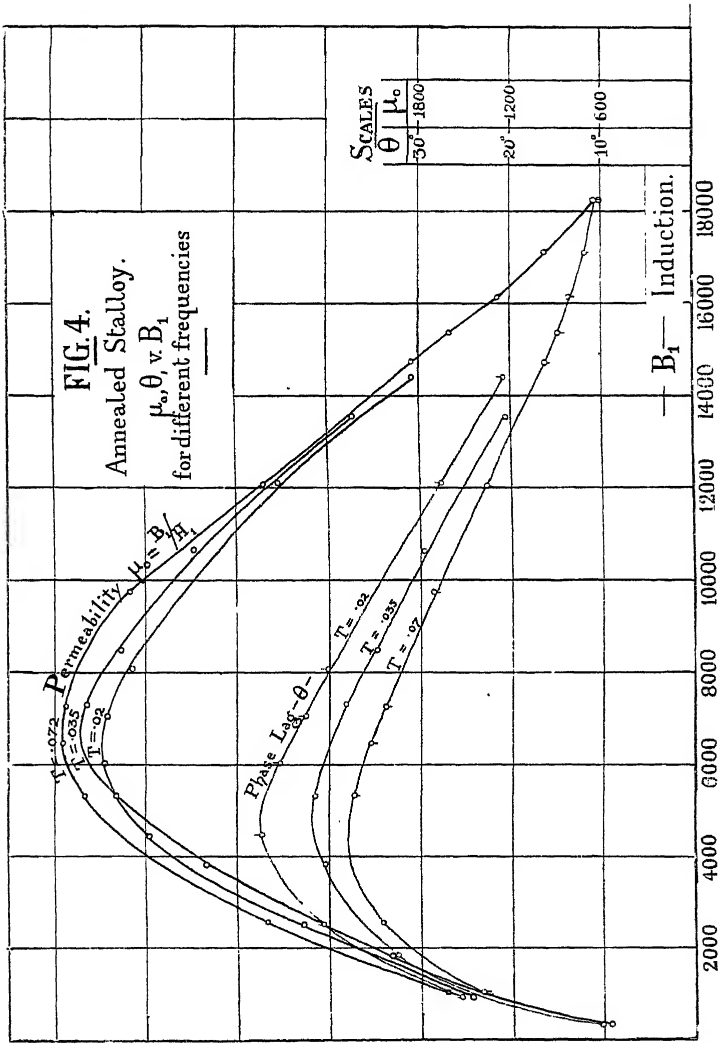


FIG. 4.
Annealed Stalloy.
μ₀, θ, v. B₁
for different frequencies
Permeability μ₀ = B₁/H₁
Phase Lag -θ-
T = ·072
T = ·035
T = ·02
T = ·02
T = ·035
T = ·07
SCALES
θ μ₀
30° 1800
20° 1200
10° 600
B₁ Induction.
2000
4000
6000
8000
10000
12000
14000
16000
18000

4500. The μ_0 graph for "Stalloy" is therefore steeper for the smaller inductions before the maximum value is reached, after this the downward gradient is more gradual than for iron and at the same time more constant. In general, for a given induction μ_0 is considerably greater for "Stalloy" than for iron.

The effect of annealing is to increase the value of the characteristic very largely. The magnitude of this increase will be best seen in Fig. 1, the corresponding curves for the other periods of alteration being very similar in appearance.

The total loss (I.) in the "Stalloy" shows a distinct improvement over that for iron. For all inductions and for all frequencies the total loss is found to be less for "Stalloy" than for ordinary iron of the same thickness. A very fair impression of the "Stalloy" total losses will be obtained by taking two-thirds of the corresponding values for ordinary iron at all inductions. It is also important to notice that these losses are greatly reduced by annealing. This reduction is not very appreciable for inductions below 5000, but above that there is a marked difference. It will be noticed however that the curves intersect where the induction is 15,500; for inductions above this the annealed losses increase very rapidly. In comparing these figures with those obtained for iron by Lyle it should be remembered that we have included the effects of the higher harmonics which in the unannealed ring were considerable. The conclusions arrived at for these total losses, namely that "Stalloy" is superior to iron in this respect and that annealing very considerably reduces such losses, although discussed for one speed only are fully borne out by the results for the other speeds as will be readily seen by plotting curves for the total loss from the other tables given.

Fig. 2a shows the effect of annealing upon the phase lag of of the third and fifth harmonics of the induction behind the first.

Both ψ_3 and ψ_5 fall rapidly from a maximum value for each as the value of B_1 is increased from zero, they then seem to reach small limiting values when B_1 is increased to high values. Here again as in the statical experiments the necessity of careful handling was proved imperative. We obtain further evidence of the instability of the unannealed "Stalloy," for in general the experimental variation from the graph is wider for it than for

the annealed "Stalloy." In one series of experiments in which the readings were extended to an induction of about 20,000 the analysis showed that all the ψ's suddenly tended towards a zero value but as the higher harmonics were so pronounced and the wave form so distorted these results are not included in the tables or graphs. That these angles tend to zero value at the high inductions may be seen by plotting the readings for Table III.

Comparison with iron show that for extreme values, i.e., for very low and very high inductions the values of the ψ's are about the same. But between these limits the "Stalloy" gradient is less steep than that for iron especially for the higher frequencies, so that in general for a given induction ψ is greater for "Stalloy" than for iron. Annealing as can be seen in Fg. 2a has the effect of increasing ψ for all inductions, this increase being more marked in the higher frequencies.

In Fig. 2b are given the corresponding curves for b_3 and b_5. These curves apparently start from the origin, rise rapidly until $B_1 = 1000$ and then steadily and gradually increase. The shapes of the curves are similar to those obtained for iron, and the values obtained about the same, a very slight increase being noticeable. Annealing makes only a slight difference in these characteristics for the low frequency, for the curves intersect more than once, and what variation there is might almost be due to instability. On plotting the figures for the higher frequencies, however, we notice a gradual decrease as was the case for iron in the values of b_3 and b_5 as we increase the frequency, as well as a marked difference between the values for the unannealed and annealed "Stalloy," which amounts in the highest speed taken to about 10 per cent. of the latter.

From a practical point of view Fig. 3 is perhaps the most interesting. In this figure the values of the total, hysteresis, and eddy-current losses are given for the annealed ring. These curves show an almost proportional increase of I and E with increase of frequency. That this should be so for E is evident, but on examination we find that I is given approximately in terms of n and $\mathfrak{B}$ for values of induction up to 11,000 by the Steinmetz analogue proposed by Lyle for iron. Namely for the annealed ring.

$$I = (.00106 + .0000226n)\mathfrak{B}^{1.55}$$

and for the unannealed ring

$$I = (.00184 + .0000331n)\mathfrak{B}^{1.5.}$$

These forms agree fairly well with experiment except in a few isolated cases occurring chiefly in the unannealed sample. The value of the exponent for each case is remarkable, for it seldom falls below 1.57 for iron.

A fair average equation for transformer iron was found to be

$$I = (.00175 + .000027n)\mathfrak{B}^{1.57.}$$

The results for eddy-current losses found by us fully substantiate the claims made by the makers of "Stalloy." The value of the specific resistance was found slightly higher than that given by other experimenters but 50,000 may be taken as a fair working value. These discs, which are much thicker (.075 cm q.p.) than those usually used in iron work, show an eddy-current loss much less than that calculated for iron of only half the thickness, the value being about one quarter of the total loss. Seeing that for "Stalloy" I is itself less than for iron, the former must be considered admirably suitable for transformer work. The values of E increase rather considerably with increase of frequency the relative increase being greater than for I. This fact will be seen from Fig. 3 which gives all the losses to the same scale.

Perhaps the most remarkable results are those obtained for the hysteresis loss U. The values for the middle frequency (.035) only are plotted in the figures; but by examining the Tables I. and III. it will be found that the values for the other frequencies practically coincide with those from which the graph is plotted. Results for ordinary iron show an increase of U with frequency which although small is still much greater than the maximum variation for "Stalloy" which occurs between the frequencies .035 and .02. The values of U for frequencies .07 and .035 are practically identical. For "Stalloy" therefore U seems to be independent of the frequency and only about half the magnitude of that obtained for ordinary iron.

The values of the "kinetic hysteresis" I-U-E are given in the tables. On plotting, these results will be found to form smooth graphs which reveal an increase of magnitude with increase of frequency. Here again the values are less than

those obtained for transformer iron. The values of U obtained by us are less than those obtained by Wilson, Winson and O'Dell, and others, but are practically identical with the results given by Barrett, Brown and Hadfield for a sample of silicon iron closely allied to "Stalloy" in composition.

Fig. 4, which shows the effect of variation of frequency upon the retardation and permeability for the annealed sample, is interesting in view of the results just referred to. In general the results show a similarity of variation to those obtained for iron, that is θ increases regularly with increase of frequency while μ_0 decreases. In both cases the maxima are reached at about the same induction, those for θ at an induction of 4500 and for μ_0 at an induction of about 6500.

One point is striking, namely, that the graphs for μ_0 for frequencies .035 and .02 intersect. Since there were a fair number of points taken and the results were very different in the two cases, this cannot be due to experimental error nor to any variation in the wave form of the magnetizing current, for the tables show this to be very constant. Corresponding to this deviation from the usual result will be noticed a distinct difference in the general appearance of the graphs for θ which is not existent in the graphs for iron. This correspondence is to be expected seeing that μ_0 and θ each depend on B_1 and ω as well as upon the wave form of H_1. Whatever deviation from the usual rule for iron there is, seems to have taken place in the middle frequency, so that for this particular frequency μ_0 is for inductions up 5000 less that one would expect. It may be possible that the previous high current densities used in the lower frequency had some after effect lasting until the maximum was reached, though precautions were taken to avoid this.

Summing up, therefore, generally, we may say that the chief results to be noticed are that—

(1) "Stalloy" cannot be used to advantage in the unannealed condition.

(2) In the annealed state the results obtained fully bear out the claims made by the makers, the permeability being very high and the losses small, particularly the eddy-current loss.

(3) The results slightly differ from those of other experimenters, the permeability being generally a little lower in our results than in theirs.

(4) "Stalloy" behaves very much like ordinary iron under varying frequencies.

(5) The constancy of the value of the hysteresis loss for different frequencies is remarkable.

In conclusion, we desire to express our thanks to Professor Lyle both for his valuable advice and kindly interest and also for placing the necessary apparatus at our disposal. Our thanks are also due to Messrs. Weymouth and Co., Melbourne, for supplying the samples used in the experiments and for stamping out and annealing the same.

EXPLANATION OF PLATES LXII.-LXV.

Plate LXII.

Graph showing permeability, retardation, total loss and eddy current loss for both annealed and unannealed "Stalloy."

Plate LXIII.

Fig. 2a.—Variation of 3rd and 5th harmonic phase-angles with the induction, for "Stalloy."

Fig. 2b.—Variation of 3rd and 5th harmonics for "Stalloy."

Plate LXIV.

Variation of the iron losses with induction for different frequencies for "Stalloy."

Plate LXV.

Variation of permeability and retardation with the induction for different frequencies.

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Art. XXVIII.—*Morphology of the Vermiform Appendix.*[1]

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AND

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(Read 10th November, 1910).

[With Plates LXVI.–LXXVa.]

Since Owen's time, but more particularly during recent years, comparative anatomy applied to the vermiform appendix has been in a state of retrogression. This fact is marked by the disappearance from current literature of description of the vermiform appendix of the wombat. (Fig 1.)

Owen, by his great ability, the possession of John Hunter's collection and the friendship of the Prince Consort, was able to employ comparative anatomy effectively. Until late in life, Owen was unhampered by religious controversy. When Huxley crushed the opposition of Owen to the law of evolution a serious setback to comparative anatomy was unconsciously given, Owen being at that time the authority on that branch of science. Thus comparative anatomy, upon which the law of evolution is largely based, became neglected on the acceptance of that law.

Since Owen's time those who have written on the comparative anatomy of the appendix have confused minute structure with shape. The work of Owen and Treves, because of its great intrinsic worth, deserves close study. The comparative anatomy

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1 The work was done in the Veterinary Research Institute, University of Melbourne, and in the Zoological Gardens, Melbourne.

in Kelly's great work on the appendix is very inaccurate. Mitchell's work on the digestive tract is riddled with error, especially his remarks on the wombat. Mitchell denies that the wombat has a true vermiform appendix. He says the wombat has two avian caeca, one of which has been mistaken for the vermiform appendix. After making this amazing statement, Mitchell says he has never seen a wombat caecum, but he has seen a drawing of a wombat's caecum by Flower.

The vermiform appendix is a peculiar caecal shape which occurs only in mammals. (Fig. 2.) To extend the study of the appendix into birds is therefore futile. Mitchell has carried the avian double caecum into mammalian work in the wombat to his own confusion. After extended observations on the caeca of many varieties of birds, we see nothing in them throwing any light on the mammalian appendix. Caecal size varies greatly in different varieties of birds; for instance, the common laughing jackass *(Dacelo)* of Australia has complete caecal atrophy, the wedge-tailed eagle *(Aquila audax)* and the lyre bird *(Menura victoriae)* each have two atrophic caeca about the size of a rice grain, the cassowary *(Casuarius)* has two caeca about two and a-half inches long. Pheasants, ducks, geese and swans have well-developed caeca. It is interesting to note that the Nankeen night-heron *(Nycticòràx)* has a single caecum like a mammal, and that the Indian python has a well-developed single caecum. The monitor *(Varanus)* is particularly interesting because he shows a caecum in the process of formation. These variations of caecal development do not, however, lend themselves so readily to explanation as the caecal variations that occur in mammals, because we know less of the habits of these animals than we know of the habits of mammals.

Since Huxley defeated Owen several facts relative to the appendix, familiar to Owen and described by him, have by later writers been displaced, but by fallacies. (Fig. 3.)

The rabbit in place of the wombat now is regarded by Mitchell as the possessor of a vermiform appendix. What does the word vermiform mean? Worm-like. (Figs. 1, 2, 7.)

Recent work on the appendix has ignored shape and devoted itself unsuccessfully to histological investigation; a result which must always follow when naked-eye anatomy is supplanted by

microscopic anatomy. That which the microscope makes clear is not the form of the tissue-mass from which the section was made, but the histological elements of which the mass is composed.

Years ago Owen saw that the peculiarity of the rabbit's caecum was that lymphoid tissue formed the caecal end. He microscoped it (Fig. 4); he also miscroscoped the human vermiform appendix (Fig. 5). He described the lymphoid tissue in the rabbit's caecal end as massed lymphoid tissue, while he described the appendix of man as containing less lymphoid tissue. It did not occur to Owen, on account of the presence of this massed lymphoid tissue, to name the end of rabbit's caecum vermiform. Owen did not regard the rabbit as showing that rare form of caecum which he thought of under the name of vermiform appendix.

Lockwood at a later date emphasised the presence of lymphoid tissue in the human appendix. Mitchell, on account of the lymphoid end of the rabbit's caecum, calls it "the vermiform appendix of the rabbit." (Fig. 3.) To quote him, "The rabbit's caecum is capacious and ends, as is well known, in a finger-shaped, narrow, thick-walled vermiform appendix." Since this loose description was adopted all sorts of caecal ends have erroneously been dubbed vermiform. No valid reason has yet appeared for repressing the original meaning of the word vermiform and twisting it to mean digitiform or distorting it to mean lymphoid.

The "abdominal tonsil" theory of the appendix has resulted from confusing things that are distinct in structure and form. Berry and Ellenberger have accepted the lymphoid tissue of the caecum as the agent that compels the vermiform appendix to come into being. To quote Berry, "The vermiform appendix is a part of the alimentary canal specialised for lymphoid function, and not a vestigial remnant."

Lymphoid tissue in an atrophic vermiform appendix should be regarded from many view points before it can be accepted as the causation of the appendix. That this lymphoid tissue is not drawn up and enmeshed in tissues during the recession of the caecum is not yet proven. The basis of lymphoid tissue is round cells. A mass of round cells must assume that shape which

their containing tissues determine; therefore lymphoid cells cannot compel form. The atrophic caecum of the cat has no vermiform appendix. It has as much, or about as much, lymphoid tissue as the human vermiform appendix. (Fig. 6.) The law governing lymphoid tissue must be the same in a cat's caecum as in a man's caecum. As the lymphoid tissue is equal in each case and the shape differs, the statement that lymphoid tissue compels form is denied by the cat's caecum. During recession of the caecum it is quite possible to believe that lymphoid tissue may offer some obstacle to atrophic processes by affording the muscular walls a content grip—a totally different process from the development of the appendix for lymphoid protection. To accept the idea that the appendix develops for the protection of lymphoid tissue in a caecum that has reached an advanced stage of atrophy compels one to believe that a duality of processes (atrophy and hypertrophy), each opposing the other, occurs at the same time in the same caecum.

The pig has a Peyer's patch about six feet long, and yet for the reception of this vast expanse of lymphoid tissue no appendix is developed. One wonders how this mass of lymphoid tissue manages to exist without a vermiform appendix when we are asked to believe that the insignificant amount of lymphoid tissue in the human appendix is the cause of the development of vermiform appendix. If lymphoid tissue compelled the vermiform appendix to develop, the intestinal tract should be studded with vermiform appendices wherever lymphoid tissue occurs. If lymphoid cells compel the shape of the human appendix, they also compel the shape of the wombat's vermiform appendix. The vermiform appendix of the wombat contains no different amount of lymphoid tissue from what is normal to the intestine. We have sectioned the vermiform appendix of three different wombats. In two of these the sections fail to show any lymphoid tissue. Mr. W. Fielder kindly sectioned a wombat's appendix for us; his first sections were like ours, negative. On prolonged search he discovered solitary follicles, a condition which he considers normal to the caecum. (Fig. 18.)

We have been unable to find any test which, applied to the lymphoid tissue of the human appendix, would lead us to believe that lymphoid tissue is the cause of the development of the

vermiform appendix. We strongly believe that an appendix cannot develop, but that it results as a vestige marking recession from a larger caecum.

Direct comparison of the rabbit's caecum with man's caecum is impossible, because there is a vast difference between the caecal evolution of man and the caecal evolution of the rabbit. A comparison of the rabbit's caecum with man's caecum is as great an absurdity as a comparison of man's brain with a rabbit's brain.

Before caecal comparison can be made, a satisfactory basis of comparison must be established. The basis of caecal comparison must be the relationship in caecal development which the compared anmials bear to their respective natural orders. The rabbit, among the rodents, is distinguished by enormous caecal development. (Fig. 3.) Man, among the primates, manifests atrophic caecal recession. (Fig. 2.) No primate shows an enormous caecal development at all comparable with the enormous caecal development of the rodent rabbit. Among the marsupials we find the koala (Fig. 19) with enormous caecal development. Therefore we believe the rabbit and the koala are fit animals for direct comparison. The koala and the rabbit each have the mucous membrane of their caeca raised in ridges for the purpose of absorption; neither caecum is sacculated by muscle bands.

The rabbit's caecum and the koala's caecum are both enormous organs, but differ in that the koala's caecum shows no lymphoid gland at the caecal end. Therefore in orderly comparison the rabbit gland turns out to be an arrangement not common, but casual to great caecal development, a glandular arrangement casual to that stage of caecal evolution.

Although the rabbit's caecum cannot be directly compared with the caecum of a primate, it is possible to institute mediate comparison by finding a rodent animal in the same stage of caecal evolution as some primate animal. The viscacha and the beaver-rat are sufficiently near the lemur (Fig. 11) to make comparison between rodents and primates possible. Neither the end of the caecum of the viscacha nor the caecal end of the beaver-rat show the lymphoid gland which is observed in the end of the rabbit's caecum. Therefore this lymphoid gland of

the rabbit is lost in procession through the rodent order. With such knowledge it is futile to pursue the investigation of the rabbit gland further. It is entirely illegitimate to believe that the rabbit's caecal lymphoid gland should make its appearance in the vestigial vermiform appendix of man or of the wombat.

Neither in external appearance nor in structure is there a likeness between the vermiform appendix of the wombat (Fig. 7) and the caecal end of the rabbit. Anatomists cannot accept each of these animals as the possessors of vermiform appendices unless they deprive the word of all sense and meaning.

A likeness has been seen by Mitchell in working out the lymphoid theory between the caecal end of the rabbit and the vermiform appendix. The lymphoid gland in the rabbit's caecal end causes such an upheaval of the mucous membrane that the lumen of the caecal end of the rabbit becomes narrowed to such an extent that its digestive function is reduced to a minimum or altogether ceases. On opening a rabbit's caecum this area of caecum is often found empty of ingesta, whilst the remainder of the caecum is distended with ingesta. The sole likeness of the rabbit's caecal end to the vermiform appendix lies in the fact that both canals are narrowed in the lumen and consequently are of little account as digestive organs. In evolutionary changes the rabbit is remotely removed from that stage of caecal involution at which a vermiform appendix becomes possible. (Fig. 8. B.) If lymphoid tissue is to take the place of shape in naming the end of the caecum, the rabbit's caecal end represents the truest type of vermiform appendix. The vermiform appendix was named before any thought was given to its contained lymphoid tissue. Since histologists mistook lymphoid cells for shape the rabbit's caecal end has been erroneously called a vermiform appendix.

The shape of the appendix depends on the muscular wall of the caecum, the outstanding cause being the external longitudinal muscle coat arranged in bands over what is regarded as the caecum, and in a sheath or sac over that part of the caecum which is called the vermiform appendix. (Figs. 2 and 7.)

Surgeons guide themselves to the appendix by following the longitudinal muscle bands. Morphologists must, in order to understand the force which compels the characteristic shape of the appendix, also follow the longitudinal muscle bands.

On the large intestines the longitudinal muscle bands are about half the length of the entire gut (man). From the shortening that these bands produce the sacculations of the bowels result. These bands commence at the setting on of the appendix from which point they diverge on to the caecum and thence to the colon. The external muscle coat can be profitably studied with the use of Treves' classical "four types of caecum." (Fig. 8,)

Type A is a cone-shaped caecum which Deaver calls infantile. It represents about two per cent. of the caeca of the civilised races. This *A type* is a caecum which has not formed an appendix; the muscle bands terminate at the narrowing of the cone into the muscle sheath enveloping the end of the caecum. It is a caecum in the immediately pre-appendicular stage. When the muscle bands that terminate at the narrowing of the cone come into activity, they deliver their pull at a point which becomes the appendicular outlet of the caecum. With the retraction of the caecal muscle bands, the caecum is shortened above the appendix, and with this shortening an increased breadth is established, due to a bellying-out of the circular fibres. Two factors operate to shut off the appendix from active digestive function—the pull of the longitudinal muscles delivered at the junction of appendix and caecum serves to produce a constriction and to shut off the appendix from the caecum proper—the sacculation of the caecum produced by the bellying-out of the circular muscle, assisted in the upright position by gravitation, leaves the appendicular opening as a small hole in a big area of caecal fundus. The caecal fundus does not act as a guide of ingesta to the appendix (Fig. 9); it so acts that food contained within the caecum engages the appendicular opening with great difficulty.

If the muscle bands continue to the apex of the caecum, as they do in the baboon, no appendix results, because the whole caecum is drawn up and no part shut off from the caecum to form a veriform appendix (Fig. 10). The lemur (Fig. 11) represents a type of caecum which, if atrophy continued in that species to the advanced stage shown in man or in the wombat, would develop a caecum carrying a vermiform appendix, providing atrophy continued along the present lines indicated by

the muscle bands and the muscle sheath at the caecal end. The lemur's caecum is much like an enlargement of a combined human type—Treves' type A and a foetal caecum (Fig. 12).

Without going outside the primate order, evidence is forthcoming of two ways in which a caecum may recede from the large to the small, as in man with an appendix and the baboon without an appendix. In the same order the lemur's caecum is that type which may recede and form during that involution a vermiform appendix.

Treves' B type which, according to Deaver, represents three per cent. of the human caeca, shows the appendix fully formed in the fundus of the caecum. It should be regarded as the earliest type of appendix. From point of origin the fundus of the caecum, to the ileo-caecal valve, is the range of atrophic take-up brought about by the pull of the mesenteric longitudinal band. Therefore one phase of caecal atrophy, in animals which develop a vermiform appendix, is a line of migration of the appendix from the fundus of the caecum to the lower lip of the ileo-caecal valve, a migration proceeding concurrently with general caecal atrophy. Before complete atrophy of the appendicular caecum can occur, the appendix must remain anchored to the ileo-caecal valve for a time which cannot, in our state of knowledge, be stated. Before that point can be approached, we must discover either a wombat or a man in which complete atrophy of the appendicular caecum has occurred. We do not think that the discovery will be made at an early date, because many human caeca are still in the early stages of appendicular evolution and the wombat (Fig. 14) is in a stationary period, his food being subjected to very slight variation. We do not consider loss of the appendix by disease a true atrophic process; at present to approach the question from the standpoint of sepsis is not a method free from solid objection. We have already said that some animals, as the baboon, will lose the caecum without the appearance of a vermiform appendix, if complete atrophy of the caecum be subsequently established in them. Primates as an order do not lend themselves to a complete study of caecal atrophy, because, as far as we know, complete atrophy has not occurred in primates. We must therefore study those changes in an order in which we have unmis-

takable evidence of complete atrophy having occurred. Because complete atrophy of the caecum has occurred in the marsupial order, accompanied by appendicular formation, the Australian order stands alone in value for the comparative study of the caecum.

Briefly considered, marsupials afford three most interesting types:—

(1) The koala (Phascolarctus cinereus) (Fig. 19), with a huge caecum.

(2) The wombat with a caecum represented by a true vermiform appendix (Fig. 7).

(3) The Tasmanian devil (Sarcophilus satanicus (Fig. 15) without a caecum.

The Carnivora throw a strong sidelight on caecal variations. No muscle bands form on the caecum, consequently caecal atrophy occurs in those animals without the formation of a vermiform appendix. The hyena has fair caecal development.

The mongoose has an atrophic caecum which would show a vermiform appendix had the arrangement of the longitudinal bands been suitable; but it has no vermiform appendix.

The Himalayan bear has no caecum. Thus in the mongoose a small caecum occurs without muscle bands; in the bear caecal atrophy has proceeded to completion. Considering the three orders, Primates, Marsupials and Carnivora, we are able to definitely state that three stages of caecal atrophy are possible.

1.—*With an appendix*, resulting from the external muscle coat forming bands on the caecum, and a muscle sheath on the appendix. (Man, Fig. 2; wombat, Figs. 14, 1, 7.)

2.—*Without an appendix,* the muscle bands terminating at the apex of the caecum. (Fig. 10.) Baboon.

3.—*Without an appendix* and without muscle bands, as in the mongoose or the domestic cat.

The variations of the external muscle coat explain the infrequency with which caecal atrophy is accompanied by the formation of a vermiform appendix.

The dog is of great interest because its caecum is distorted by peritoneal adhesions. About the distortion of the dog's caecum and the appendix of man a common cause operates, viz., peritoneal adhesions. As both man and dog are irregular and

erratic feeders, the question arises whether the distortion seen in the dog's caecum and in man's appendix are due to adhesions contracted during varying distentions of the digestive tract which shift these organs into varying positions.

Treves' type C is, perhaps, from an anatomical standpoint, the least important of his types. It represents the commonest type found in man (the normal caecum of Deaver), and thus assumes an importance on that account alone. It represents the migration of the appendix half way between the fundus of the caecum and the ileo-caecal valve, a migration due to the pull of the mesenteric muscle band.

Treves' type D, also Fig. 16 and the caecum of the wombat (Figs. 1 and 7) are alike. In each case the appendix opens on or into the lower lip of the lieo-caecal valve, having been dragged to that position by the pull of the mesenteric muscle band. Under the pull of this band, atrophy on its side is established earlier than on the free side, and the drag of the mesenteric band is transmitted to the colon, which assumes a position mimicing caecum when caecal atrophy becomes extreme. The caecum on the free side atrophies as the sphincteration of the colon eases under the influence of diet of less bulk and greater nutritive power. In the human caecum variations of type D occasion much confusion during surgical operations. These confusing caeca have been under the influence of a preliminary artophy which has subsequently been subjected to caecal distension. Fig. 13 shows this condition. The point of interest is the U-shaped longitudinal band which offers clear evidence that the colon has been dragged down either by distension or this force plus gravitation.

We have examined a number of Victorian wombats' caeca. (Figs. 1-14.) They all show Treves' D type caecum—the appendix of a small size. A wombat's caecum sent us by Mr. Desmond from South Australia (Fig. 7) is also of Treves' type D; its appendix, however, is about three times the volume of the Victorian's. Perhaps we have an abnormally big appendix from South Australia; perhaps food differences in the two States explain the lesser atrophy shown by the wombat of South Australia. This is a point which should be cleared up. In a paper published in the "Australian Medical Journal" of 20th

August last, the caecal changes due to food were dealt with. It remains for us to point out that although the state of the bowel development depends wholly upon food taken under the process of natural selection, yet when deductions are drawn from comparative anatomy, those deductions must be controlled by a knowledge of the trend of the order. A study of marsupials, for instance, creates the belief that marsupials are more responsive to food change than primates. The extreme atrophy of the caecum in the wombat occurs on a nutritious diet composed wholly of vegetable matter. When we reflect on the fact that the koala nourishes its tissues wholly on gum leaves, we are struck by the wonderful constructive power of the koala's (Fig. 19) intestines, which convert into strong animal tissues that which to other animals is an indigestible poisonous scented fibre. This higher digestive efficency explains why the wombat shows caecal atrophy upon a diet which, if taken by man, would require a considerably larger caecum than he has now.

The difference between type D, human appendix, and the wombat's appendix is one of distortion. The human appendix being distorted by erratic peritoneal adhesions, the wombat's appendix being straight.

An amendment of Treve's four types of caecum is necessary, because in those types is not included the foetal type, which differs from type A in showing no longitudinal muscle bands.

Preappendicular types—

Type A, No. 1—Foetal caecum. No bands. (Fig. 12).

Type A, No. 2—Infantile caecum. Banded. (Fig. 8 A).

Appendicular types—

Type B—The earliest appendix or fundal appendix. (Fig. 8 B).

Type C—The intermediate appendix. (Fig. 8 C).

Type D—The late or ileo-caecal appendix. (Fig. 8 D).

The foetal caecum is proportionately bigger than the adult caecum (man).

Foetal measurements (8 months estimated)—

Stomach and small intestines -	1.04 metres
Caecum - - - - - -	.06 "
Large intestines - - -	.24 "

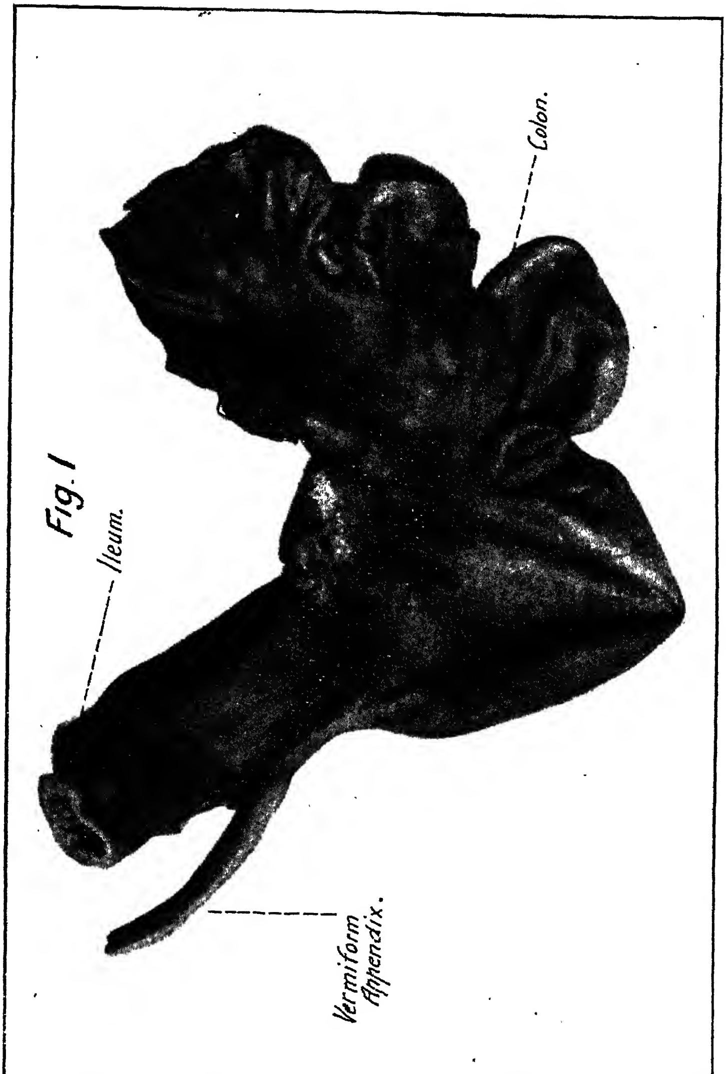


Fig. 1
Ileum.
Colon.
Vermiform Appendix.

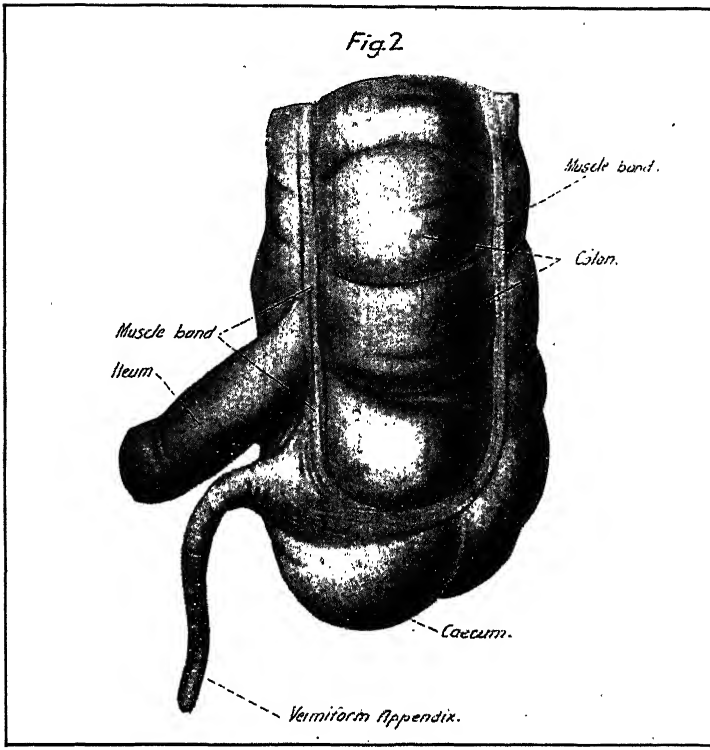


Fig.2
Muscle band.
Colon.
Muscle band
Ileum
Caecum.
Vermiform Appendix.

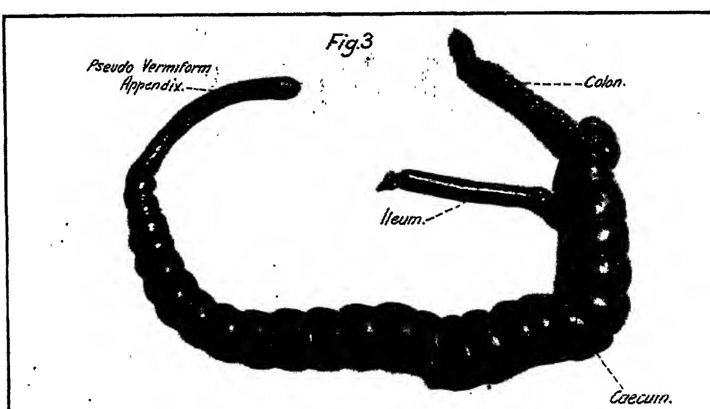


Fig.3
Pseudo Vermiform Appendix.
Colon.
Ileum.
Caecum.

Fig. 4

Fig. 5

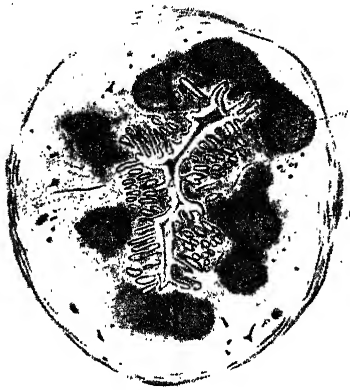
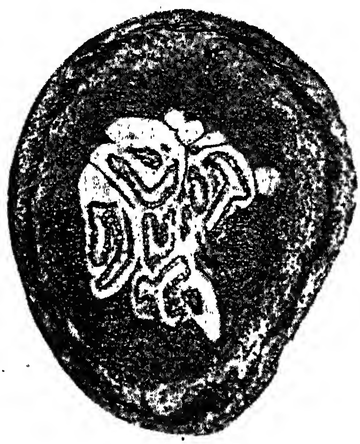
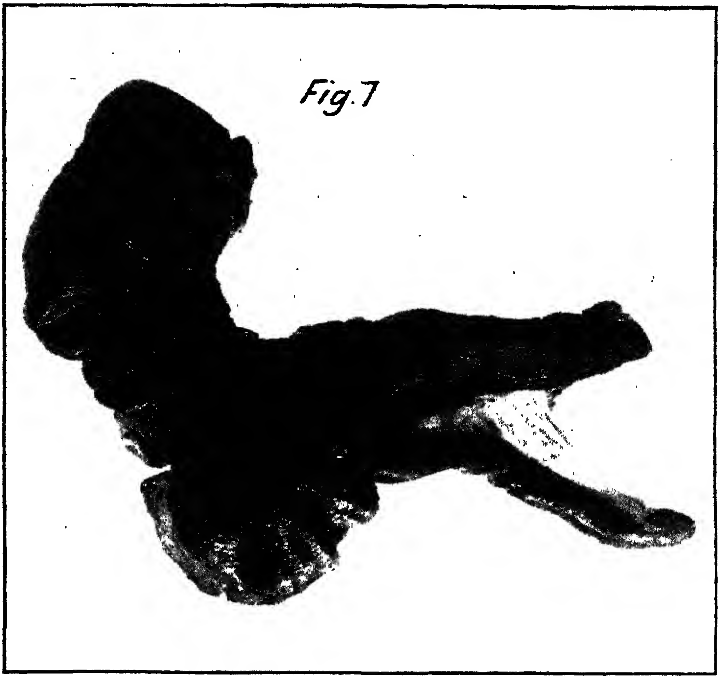


Fig. 6





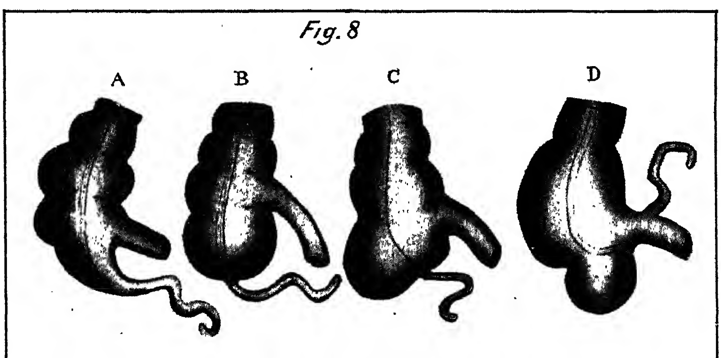


Fig. 8
A
B
C
D

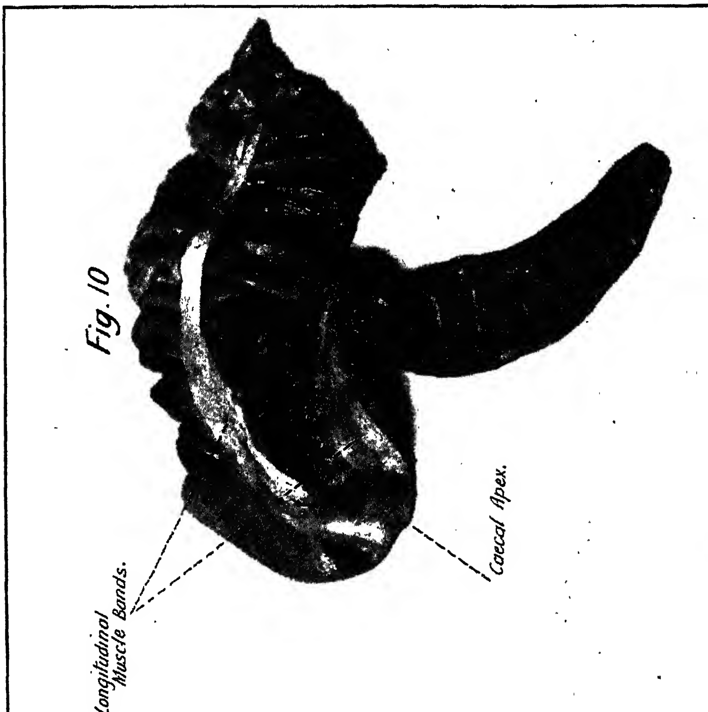


Fig. 10
Longitudinal Muscle Bands.
Caecal Apex.

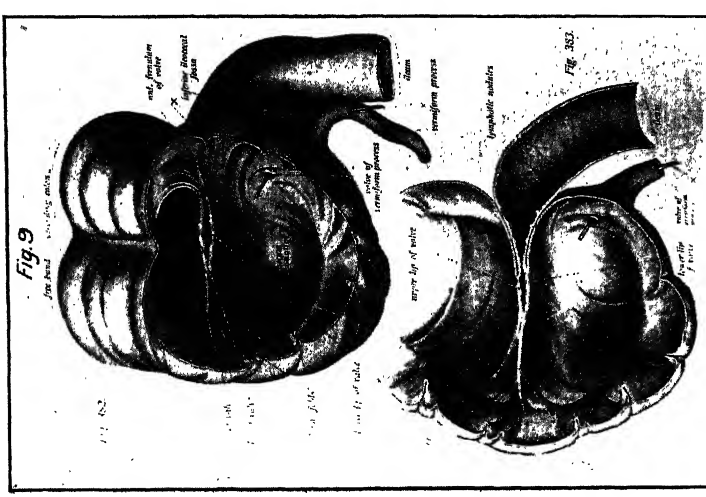


Fig. 9

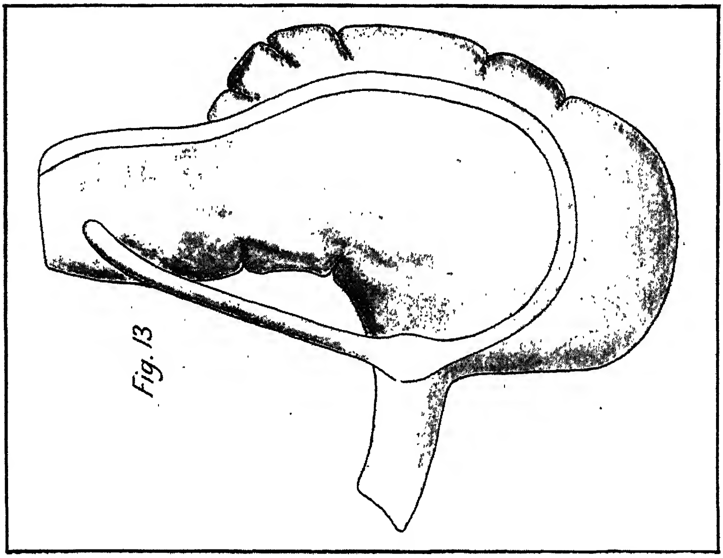


Fig. 13

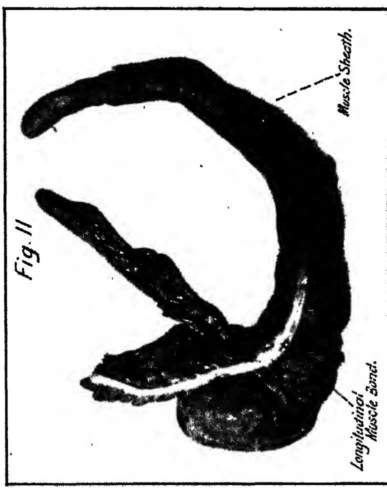


Fig. 11

Fig. 12

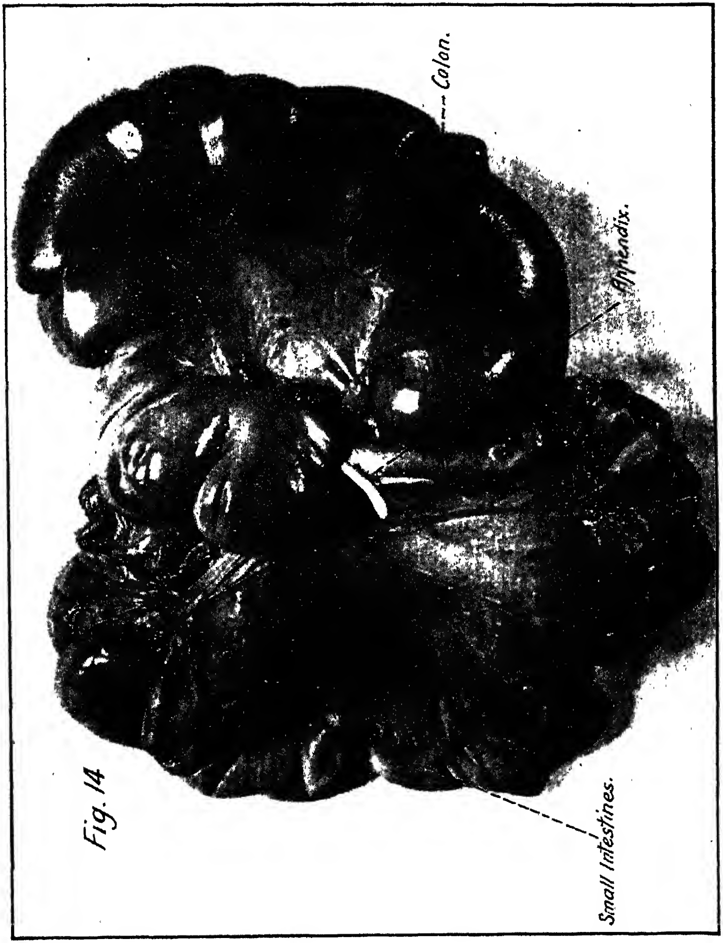


Fig. 14

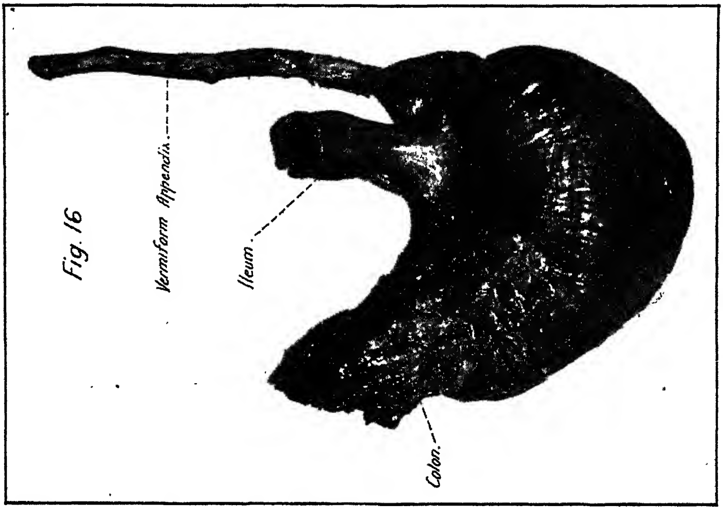


Fig. 16

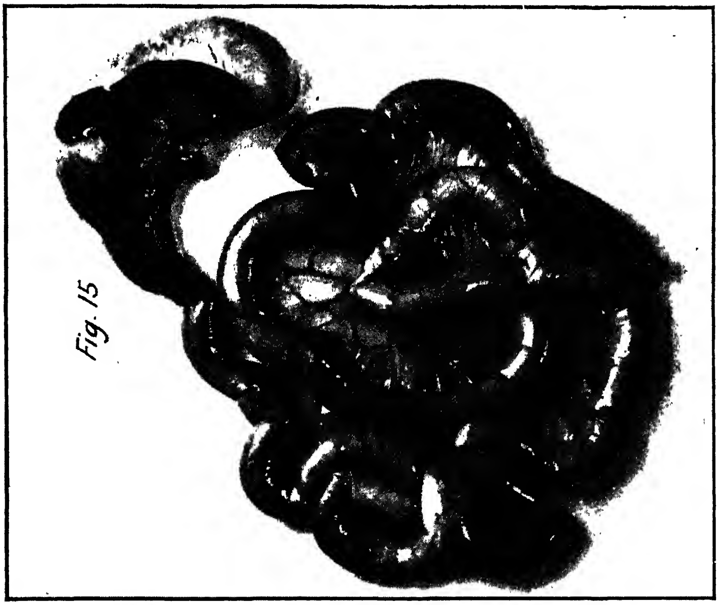


Fig. 15

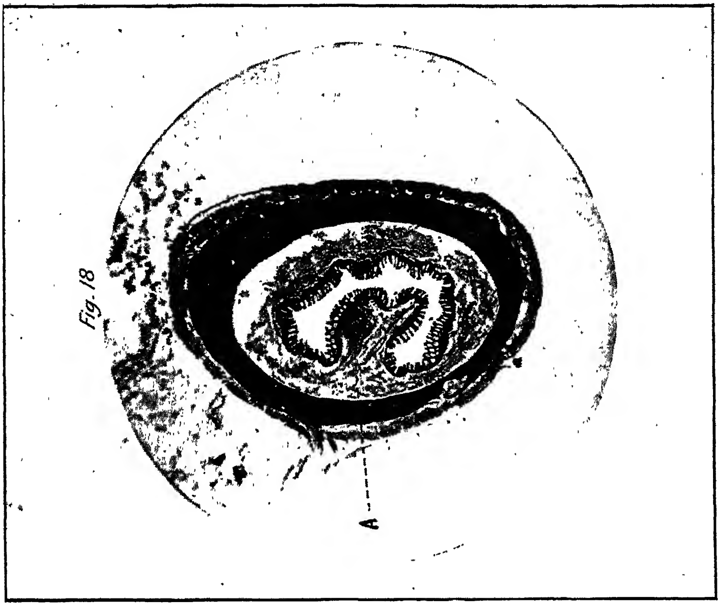


Fig. 18

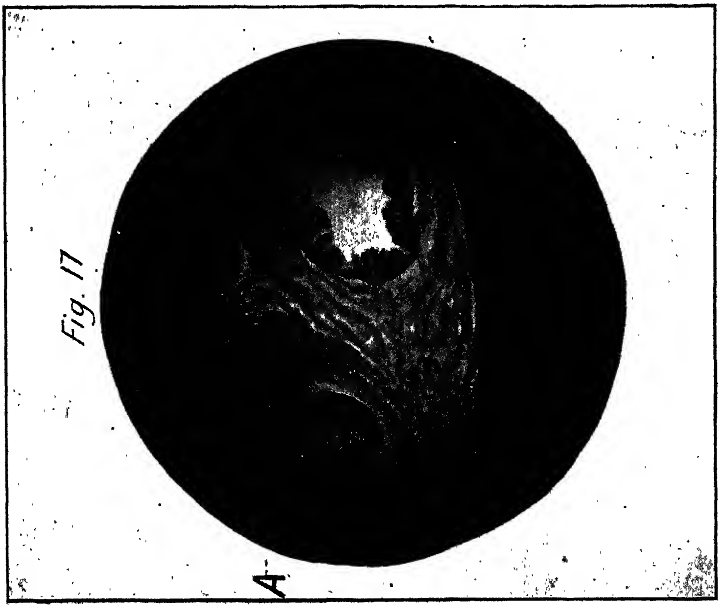


Fig. 17

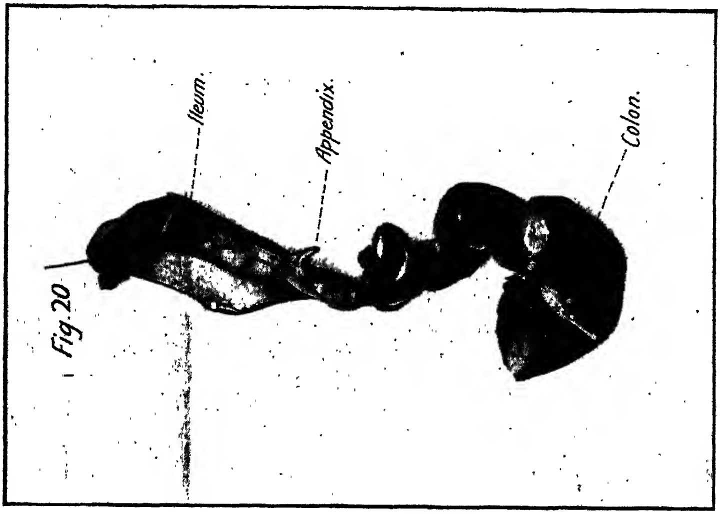


Fig. 20

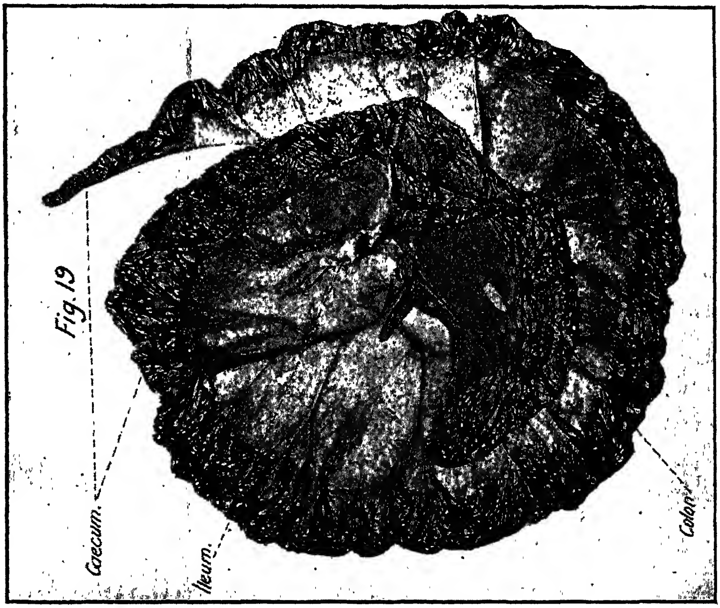


Fig. 19

Adult measurements (Morris)—

Stomach - - - - -	.30 metres
Small intestines - - -	8.00 „
Large intestines - - -	1.40 „
Appendix - - - - -	.10 „
Caecum - - - - -	.06 „

In the adult the proportionate increase of length from foetal type is :—

Stomach and small intestines -	Eight times
Large intestines - - -	About six times
Caecum and appendix - -	Less than three times

In the foetus the caecal ratio is about one to twenty-two; in the adult, about one to sixty-one.

In studying the five human types we observe that the foetal caecum is a relatively larger organ than an infantile caecum, for this has become shortened by the pull of the muscle bands which are set into the muscle sheath, the sheath which in type B becomes the appendix. From this stage in caecal atrophy the most easily followed atrophic process is that along the mesenteric muscle band. This process enables the appendix to migrate from the fundus of the caecum to the ileo-caecal valve—a migration going on concurrently with general caecal atrophy. Figs. (type B, Fig. 8, and type D, Fig 8.)

The recession of the human caecum from large foetal type to small adult type is marked by a peculiar variation in the external muscle coat through which, by the pull of the muscle bands on the muscle sheath, an appendix is formed.

The five types of human caecum indicate that during modern times caecal atrophy has been progressing at varying speeds, due to sections of the race adopting foods of different bulk. Rapid food changes have occurred concurrently with material progress and increased transportation facilities. Those in type D have been for a long period taking food of small bulk and high nutritive quality; those in type A have remained on the bulkier food of their ancestors or a food more bulky than is used by type D. Type C—the intermediate type—represents the mean of these extremes; it is the common type. Upon the embryological principle "that the higher types pass through stages during their development that are permanent in some

of the forms below them in the scale of evolution," the recession of the caecum from a longer type is established. Those who deny that the appendix is a vestige of a larger ancestral caecum have the weight of embryological evidence again them.

Heisler's embryology says:—"In the third month the appendix has already acquired the form of a slender curved tube projecting from the caecum. At the time of its first appearance and for some weeks later the appendix has the same caliber as the caecum. Subsequently the caecum outstrips the appendix in growth, the latter appearing in the adult stage as a relatively very small tube attached to a much larger caecum."

The claim that is made that the appendix is a development and not a recession is refuted by a macroscopic study of the anatomical types of caecum, by a study of the embryology of the appendix and caecum, and by studying the lines of force that go to determine the appendicular shape. Upon such lines it is quite easy to follow during atrophic processes the formation of the vermiform appendix, but it is not possible to understand the development of an appendix. The vermiform appendix cannot be developed. It can only be formed during recession of the caecum. Development cannot occur because development implies an increased caecal content, and an increased caecal content exerts its force against the fundus of the caecum and not against the appendix. (Fig. 13).

Leaving the subject of caecal changes in man, we will deal with caecal changes in the only order besides primates that has an animal which shows a true vermiform appendix—the marsupial. Outside primates, the only animal that has an appendix is the wombat. (Figs. 1-7.) There are many points of strong resemblance between the wombat and the koala (Fig. 19), for it is highly probable that at an early date they were closely related. The koala took to the gum trees and lived exclusively on gum leaves; the wombat took to the ground and lived on roots and other food less bulky and more nutritious. The history of this change of food is to be seen in the caecum of these animals. The koala has an enormous caecum to digest its gum leaves, the wombat has only a vermiform appendix to represent its caecum; otherwise the digestive tracts of the wombat and the koala are alike. The Victorian wombat (Phascolomys

mitchelli), Fig. 1, has a small appendix and complete atrophy of the remainder of the caecum. With this complete atrophy the muscle bands on the colon have become faint or they have disappeared from view. The wombat sent from South Australia (Phascolomys latifrons), Fig. 7, has a larger appendix than the Victorian (Fig. 1), and the caecal atrophy is less complete; muscular bands are well shown on the colon, Fig. 7.

Measurements—

	Caecum	Verm. appen.	Stomach	Colon	Sm. intestine
Koala - -	2.30	—	.35	3.80	1.07
Wombat (young)					
P. mitchelli -	.02 ?	.012 ?	.08	.65	1.73
Wombat (adult)					
P. mitchelli -	.05 ?	.05	.50	5.60	3.27

In the Koala the ratio of stomach to small intestine is

Stomach - - -	0.35
Small intestines -	2.07

or rather less than one-sixth.

In the Wombat the ratio of stomach to small intestines is

Stomach - - -	0.50
Small intestine -	3.27

or about one-sixth.

In the koala the ratio of large bowel to small bowel is 2.30, plus 3.8, equals 6.10 of large bowel upon 2.07 of small bowel, which roughly represents a preponderance of large gut over small of 3 to 1.

In the wombat the large bowel is 5.65, the small 3.27, or, roughly, 1½ to 1. This represents the ratio of large bowel atrophy which has occurred in the wombat.

Fig. 20 is an infantile wombat caecum. Its measurements were made before we had worked out the forces of appendicular formation, and we consider that these caecal measurements demand support by measurements of further specimens before we consider them acceptable. We shall therefore refuse to be guided by the figures indicated by a query. It is quite clear, however, that during the formation of the appendix in the wombat the caecum as a functioning intestinal organ has been lost by atrophic changes.

The Tasmanian devil, having no cellulose to digest, and taking

a carnivorous food, has only 1.9 metres of stomach and intestinal tract. (Fig. 15.)

Generalisation and Summary. In Keen's surgery we read: "It is an established fact that appendicitis is more prevalent in some families than in others. On the other hand certain families seem to have complete immunity against the disease. Lucas Championnier, 1904, analysing 22,000 patients among Roumanian peasants, found but one case of appendicitis; they live mostly on vegetables. The Roumanians in the city, chiefly on animal diet, are frequently affected, one case of appendicitis among every 221 patients. The vegetarian diet of the Japanese and the Indians in India seems to protect them against appendicitis. The absence of appendicitis among the Arabs living in tribes and on vegetables, with its prevalence among those in cities where meat is the chief diet, has already been spoken of."

These observations agree with widespread medical opinion; it does not necessarily follow that they are wholly correct. The Zulus are great meat eaters. South African surgeons should settle the point whether Zulus are often attacked with appendicitis. We are inclined to the idea that appendicitis is as rare amongst Zulus as amongst other savages; the Zulu on his meat diet is built on athletic lines, the Indian coolie on his rice food is a miserable specimen of humanity compared with the robust Zulu. It seems to us that the meat theory of appendicitis is not firmly established, and widespread scientific investigation of the influence of food on bowel structure is required.

When such careful investigation is made, we believe that instead of blaming meat alone for causing appendicitis no special food will be blamed; but that it will be shown that any food of small bulk and high nutritive quality if taken by an animal used to a bulkier food containing cellulose for a long period, causes atrophy from disuse of the caecum. After studying many forms of intestines it becomes impossible to escape the belief that the function of the bowels dominates their development. Comparative anatomy is waiting for the establishment of the anatomical types of caecum that prevail among the races of mankind.

The wombat, being the only animal outside the Primates showing a vermiform appendix, lends a peculiar Australian interest to the study of the morphology of the vermiform appendix. The wombat completely refutes the theory that the

vermiform appendix is developed for lymphoid tissue. With this lymphoid theory swept away the older and correct theory remains established. The vermiform appendix is the vestige of a larger ancestral caecum. Practically it has no function, its small size denoting loss of function by atrophy.

The appendix is a rare form of caecal involution which is due to the peculiar arrangement of the external muscle coat of the caecum (longitudinal bands on the caecum terminating in a muscle sheath on the vermiform appendix).

DESCRIPTION OF PLATES LXVI.-LXXVA.

1. Wombat (Phascolomys mitchelli). Caecal area showing vermiform appendix.
2. Human vermiform appendix.
3. Rabbit's caecum showing pseudo-vermiform appendix.
4. Section of rabbit's caecal end showing massed lymphoid tissue
5. Section of human appendix showing lymphoid tissue.
6. Section of kitten's caecum showing lymphoid tissue surrounding the mucosa.
7. Wombat (Phascolomys latifrons). Caecal area showing vermiform appendix.
8. Treves' four types of caecum.
9. Outlet of appendix into caecum.
10. Baboon's caecum showing bands terminating at apex of caecum.
11. Lemur's caecum showing bands terminating in muscle sheath.
12. Foetal caecum, human.
13. D type of caecum showing U-shaped muscle band resulting from distension following atrophy.
14. Intestines of wombat.
15. Undifferentiated intestinal tract of Tasmanian devil (Sarcophilus).
16. Human caecum like a wombat's caecum.
17. Section of wombat's caecum. *A*. Solitary lymphoid nodule.
18. Section of wombat's caecum. *A*. Solitary lymphoid nodule.
19. Koala's caecum.
20. Young wombat's caecal area showing appendix.
21. Caecal area, ileum, vermiform appendix, and colon. Flinders Island wombat (Phascolomys ursinus).

Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. II., 1911.]

Art. XXIX.—*Some Observations on the Comparative Anatomy of the Fibula.*[1]

By WILLIAM MACKENZIE, M.D., F.R.S. (Edin.).

(With Plates LXXVI.—LXXVIII.).

[Read 10th November, 1910].

Bone serves various uses in the animal economy. Of its subservience to muscle there are numerous instances scattered throughout the comparative world. Thus, muscle dominance produces a broadening of the bone surface where muscle attachment is required, and a narrowing or rotundity where such attachment is diminished or absent, compactness or lightness of bone where strength or otherwise is requisite, and bony ridges, and projections to afford leverage, as, for example, in the case of the attachment of the two thigh flexors in the leg of the Koala *Phascolarctus*. As obviously the erect position adopted by man and consequent mode of progression have impaired the function of numerous muscles throughout the body, recognition of accompanying bony changes becomes a matter not only of comparative, but also of surgical interest.

If we regard the extremities, one would naturally expect such changes to be more marked in the lower than the upper limb, and indeed that is so. Man's hand not distinguishable much from that of the tree climber, and having independent thumb action is capable of numerous possibilities of adaption, though Koala with his two thumbs is to be envied; but in the lower limb which we use solely for ambulation no longer have we the approximating Hallux of the Koala or Lemur—we simply require a broadened surface for support; the intermediate position between the Hallux of man and of the Lemur or Koala being seen in the Baboon. Associated with this alteration of

1 The work in connection with this paper was done in the Anatomical Department, Veterinary School, Melbourne University.

the position of the Hallux and the loss of power of adduction we have an impairment of the mobility of the foot, the diminished call for work resulting in lessened extent and variety of muscular activity and subsequent changes in the bones of the leg.

In the upper limb associated with the adduction of the thumb we have the movements of pronation and supination, and for this, two forearm bones are necessary. In the Koala and Lemur with great mobility of the feet, the uses of which are almost, if not as great as those of the hand, we find both bones of the leg, namely, the Tibia and Fibula well developed and in the Koala little distinguishable in size, and both entering into the formation of the ankle and knee-joints; but in man and the Kangaroo, where the erect position predominates and support only is requisite, the question of the utility of a second bone in the leg is raised.

Hence a comparison is necessary, the basis of which depends on the mobility or otherwise of the ankle-joint which is itself a natural association of an approximating Hallux.

Before entering into this consideration a brief review may be made of the Fibula as occurring in man. Although the Tibia —the companion bone in the leg—is the longest and largest in the skeleton excepting the Femur, the Fibula is on the other hand, in proportion to its length, the most slender of all the long bones. Its upper end forms no part of the knee-joint, its chief function being to increase the surface for muscular attachment, while at the lower end it supports the outside of the ankle-joint. It may, though rarely, be completely absent, an instance of which Hughes reported at a recent meeting of the Intercolonial Medical Congress. In some instances the upper and lower ends may be distinct, the shaft having disappeared, being represented but by a thickening of the interosseous membrane connecting the two ends. In fact congenital absence of part of the bone is more frequent than that of the whole bone, which when present causes great disability of the foot and difficulty of ambulation, not on that account only but owing to its frequent association with an imperfect development of the tarsal bones and an absence of one or more of the four outer toes.

A not infrequent condition is a separation of the shaft into two portions at the junction of the middle and lower thirds. Though unassociated with disability in walking yet in some cases the ends may form prominences beneath the skin for which the surgeon may be consulted. That there is a lack of resistance of the narrow lower third of the leg is undeniable, affecting not only the bony structures but the soft also, since Rickets here first manifests itself, and ulcers of the leg are usually met with at this spot.

Associated with the narrowing of the lower third of the leg which is necessary for activity of movement, since size and weight would impede locomotion, we have practically no origin of muscular fibres; the muscles are becoming more or less tendinous; they lie close to the bones and are held firmly in position by strong bands of fascia.

It will now be necessary to enter on a description of the Fibula as it occurs in animals of different species, the animals chosen having undoubtedly an important bearing on the comparison.

Koala *(Phascolarctus cinereus)*.

In both the Koala and the Australian Phalanger with the hind foot broad and an opposable and serviceable Hallux there exists a greater freedom of movement between the Tibia and Fibula than in others of the marsupialia, approaching in some degree to the rotation between the Radius and Ulna. In Koala the disproportion between the Tibia and Fibula is slight and excepting the monitor lizard (*Varanus*) less than that occurring in the other forms examined. The head of the bone is well developed and articulates with the Sesamoid bone in the outer head of the Gastroenemius with the outer tuberosity of the Tibia and also with the outer condyle of the Femur, so that it partakes in the knee-joint. The lower end is well developed, with the outer Malleolus slight, and the Fibula is seen to play as almost an important part in the formation of the ankle-joint as the Tibia.

Lemur (*Lemur catta*).

Here as in the case of the Koala there is a wide range of movement at the ankle-joint and the Fibula is well developed

and distinct all through from the Tibia. Above we find the outer tuberosity of the Tibia forming a smooth projecting rim round which the head of the Fibula is allowed to play, resembling somewhat the condition found in the Radius and Ulna of the forearm. The lower end is well developed and takes an important part in the formation of the ankle-joint. There is good muscular attachment of the Extensor muscles and Peronei along the shaft of the Fibula. The disproportion between the two bones is not so marked as in man or the higher mammalia.

"Opossum" (*Trichosurus*).

Here we have introduced as accessory to the use of the fore and hind limbs that of the tail. There is a well-marked disproportion between the Tibia and Fibula and both the upper and lower ends are less defined than in Koala. Furthermore the lower end partakes less in the formation of the ankle-joint.

Wombat (*Phascolomys*).

Here the disproportion in size between the bones of the leg is very pronounced—the atrophying Fibula and the enlarging Tibia being well shown. The Interosseus muscle in contrast to other parts of this marsupial's musculature shows marked evidences of fibrous degeneration. The shaft is complete and the upper end articulates with the Femur and Tibia and also with the Sesamoid Bone. At the ankle-joint the chief articulation is between the Tibia and the Astragalus and the Inner Malleolus partakes in the articulation; but the Outer Malleolus though well developed does not. Below there is a well marked Firbro-cartilage evidently to increase the surface of Fibula for articulation.

Kangaroo (*Macropus*).

Here the lower half of the Fibula as a distinct separate bone has disappeared and the evidence of such is distinguished by a groove. The upper half is distinct and separated from the Tibia though fused to that bone at its lower end. The head is poorly formed though it articulates with the Sesamoid bone and the Outer Tuberosity of the Tibia.

Carnivorous Marsupials

(*Dasyurus viverrinus* and *Sarcophilus satanicus*).

In both the native cat and the Tasmanian Devil we see a marked disproportion between the Tibia and Fibula. These animals represent, with their long Pes and close approximation of Tibia and Fibula below, an approach to the Kangaroo type. The head articulates with the Tibia and the Sesamoid bone. Below the amount of surface entering into the formation of the ankle-joint is insignificant and chiefly through the intervention of the Fibro-cartilage present. The bones are well separated throughout the shafts, but approach below and are firmly bound together. These features are more marked in the Cat (*Dasyurus*) than in the Tasmanian Devil.

Echidna (*Tachyglossus aculeatus*).

Here we have the presence of a Hallux, though not nearly so distinct as in Koala. The shaft of the Tibia is larger than the Fibula, although the disproportion is not very marked. At the upper end we get the prolongation into a broad, flattened process resembling an olecranon, and articulating with both the Femur and Tibia. The lower end is well developed and partakes almost as freely in the formation of the ankle-joint as the Tibia.

Lace Monitor (*Varanus varius*).

In this Australian reptile, where a great mobility of the foot is permissible, we have a much larger Fibula than Tibia, not only as regards the shaft but also at the upper and lower ends. The principal articulating surface both below with the Tarsus and above with the Femur is supplied by the Fibula.

Armadillo.

Both bones are commonly ankylosed together at each extremity but the shafts curve away from each other, leaving a wide interosseous space.

Hare (*Lepus europaeus*).

This animal, with his long foot at a right angle like the Kangaroo, and able also to sit up, shows an even more advanced type of disappearance of the Fibula than seen in that marsupial. Only the upper third remains. No trace of the lower half can be distinguished. The lower end of the fragment is fused to the Tibial shaft, and the upper extremity is fused to the outer Tuberosity of the Tibia.

Sheep (Bovidae).

The Fibula as such has disappeared. There are no evidences of it above, except a well marked fibrous band extending from the External Tuberosity of the Tibia to just above the middle of the shaft of that bone. On the lower, articular face of the Tibia a groove is seen representing the former separation of the Fibula.

Deer (Cervidae).

Here the Fibula has disappeared, the only trace being a bony spicule about three-quarters of an inch long, depending from the outer Tuberosity of the Tibia.

Mongoose (*Herpestes*).

Here we have long feet giving a good base to allow for springing. The Fibula is thin and slender especially in the upper third. There is an ill-defined articulation above with the outer Tuberosity of the Tibia. The lower end does not partake in the formation of the ankle-joint acting merely as an outside support to the articulation.

Horse (*Equus*).

The Fibula is represented by a spicule of bone abutting down from the Outer Tibial Tuberosity. The Koala does not depend on the peloic limb for propulsion speed nor for continuous support. Where high speed continued over long periods is necessary, as in the horse, a bone like the Fibula would undoubtedly weaken the Tarsal articulation.

Agouti (*Dasyprocta*).

Here we obtain marked evidences of the disappearing Fibula, which has assumed a thin almost transparent cartilaginous character with a transparent interosseous membrane. At the upper end no true articulation even with the Tibia is seen, it being retained in position by fibrous bands. It is closely attached to the Tibia below and takes only a very slight part in the formation of the ankle-joint by articulating with the small outer facet on the astragalus.

Buffalo (*Bubalus*).

A groove is seen on the lower articular face of the Tibia representing the original separation of the Fibula. The only representation of the Fibula is a thick fibrous band from the Outer Tuberosity of the Tibia to the junction of the upper and middle thirds of that bone.

Cat (*Felis domestica*).

This animal is able to spring and can broaden his base when sitting by resting on the whole foot. Here we get a slender rounded Fibula tightly attached, especially below to the Tibia. This rotundity shows the absence of necessary muscular pull; the lowest ratio of area to volume is found in the spherical form and for muscular attachment we require area—i.e., surface. It articulates above with the Outer Tuberosity of the Tibia and below enters slightly into the formation of the ankle-joint through the outer facet of the Astragalus.

Baboon.

Here we have a contrast with the Lemur. There is a distinct separated Hallux, but approaching the Anthropoid type. The formation of the ankle-joint with its deep socket and having both Malleoli projecting well down laterally is opposed to lateral movement. The Tibia and Fibula are well bound together and there is little elasticity present. In the Lemur the Fibula articulates with the upper surface of the Astragalus.

In the Baboon the outer Malleolus articulates with the outer facet on the Astragalus, there being a marked ridge separating the upper and the outer surfaces not met with in the Lemur. There is more marked differentiation between the Tibia and Fibula than in the Lemur, and the Fibula is more rounded. There is not the lipping at the outer Tuberosity for easy articulation, as in the Lemur, although some movement is allowable; but the bones are much more firmly attached.

Conclusions.

That the Fibula is undergoing marked evolutionary changes is undeniable, and no doubt the condition in the Kangaroo points the way. Possibly the absence of the Fibula with loss of the outer toes seen occasionally in congenital cases in man serves as an indication of ultimate destination; though obviously here Nature creates a condition for which the erect position has not yet educated itself. Processes of this character are slow and gradual, as seen in the Marsupial, where, as in the Kangaroo, by a fusion to the Tibia, and so a broadening of its surface and strengthening the outer ankle, the bone still performs a function. In the cases of congenital absence of the bone it would be interesting to know had the Fibula really disappeared or was there a fusion to the Tibia, and so a broadening of its surface? In man the marked contrast between the relative size of Tibia and Fibula, and the fact that the latter has been pushed from the knee-joint, and partakes little in the formation of the ankle-joint are indications of its retrogression. The shaft of the bone is undoubtedly thinning, and scarcely do we find two bones alike in size, whilst at the same time the Tibia is uniformly broad and compact. From previous considerations one would naturally expect changes to occur at the lower third of the bone, and thinning is in my experience most marked here, of which the so-called congenital fractures must be regarded as advanced evidences. Probably these cases of so-called fractures are best undetected as the question may be raised of reconstituting the Fibula, i.e., a bone becoming obsolete in the animal economy. One might expect a better result to be obtained if the ends projecting under

the skin were removed, or an endeavour might rather be made to attach them to the Tibia. On the other hand, cases of congenital absence of the Fibula in man, since, as before stated, it may be associated with absence of outer toes, but occasionally with loss or deformity of the inner toes, are associated with impairment of gait and operative interference is necessary. The loss of inner toes seems to have caused difficulty to surgeons in explaining, but the reason is easily understood on comparative lines. On examining the foot of the Kangaroo we see two degenerate inner toes, a powerful middle toe, which is practically the continuation of the foot, and a small, though intermediate, outer toe. No doubt the position and length of the middle toe have been the determining factors in its natural selection; but in spite of this change in the foot the Fibula is not congenitally absent, as a reference to the description will show. Thus from a consideration of the mode of disappearance of the Fibula in animals master exponents of the same mode of progression as Homo Sapiens exhibits, it is obvious that in causing a congenital absence of the Fibula to occur in man, Nature has carried the progress of one of the consequences of the erect position, and associated gait beyond that of the other consequences with which it should be co-ordinate, although she may thereby give us a hint of to what this evolution is tending. In other words, if the consequences of the assumption of the erect attitude with its associated gait are manifold, and must in the type which will be naturally selected and eventually persist be co-ordinate; and if Nature has in these congenital Fibulae cases allowed one member of the associated group of consequential processes to progress disco-ordinately in advance of the rest, it suggests itself that the indicated method of correction of the natural error lies along either one of two directions. Firstly, bringing back the advanced member, e.g., plastically replacing the undeveloped mid-fibula; or, secondly, recognising and permitting the condition of this disco-ordinate member, and artificially re-establishing co-ordination through the other members of the associated group of consequences of the assumption of the erect attitude and gait.

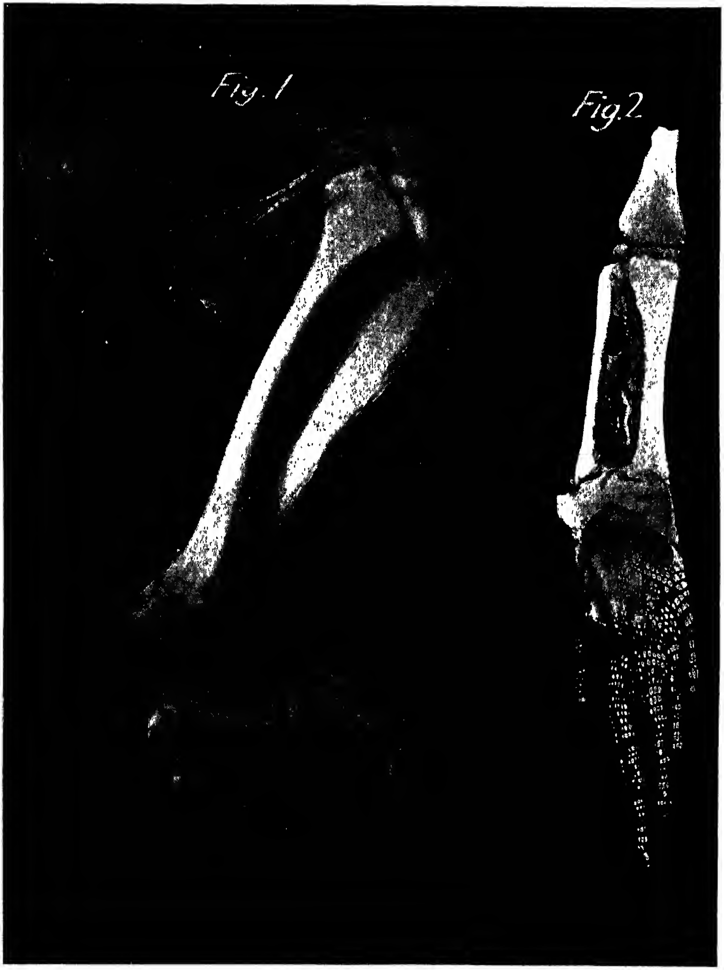


Fig. 1
Fig. 2


Fig.3
Fig.4

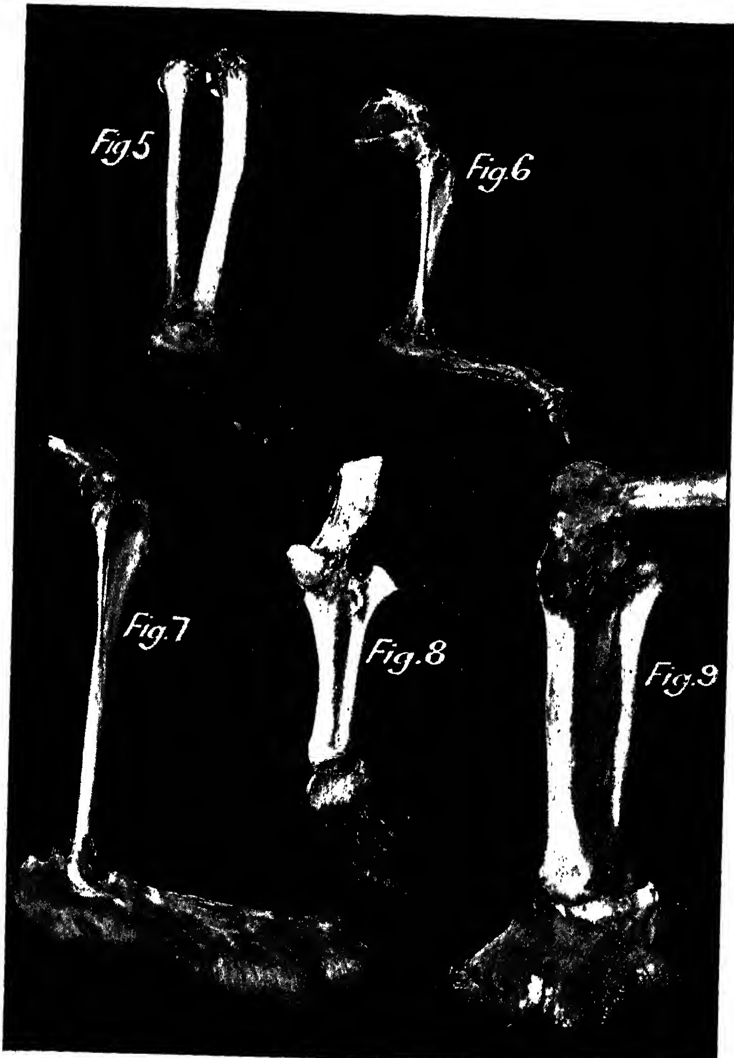


Fig.5
Fig.6
Fig.7
Fig.8
Fig.9

So when one comes to the question of which of the two lines is the correct one to follow one must decide for the latter—or deny the doctrine of evolution, and ignore the results of comparative anatomy.

It is a decision arrived at on philosophical grounds, and without appeal to the question of expediency, involved in the deficient vitality, and hence of energy of repair in the atrophying parts, upon which one depends for union in the plastic operation—apart from the difficulty of obtaining suitable human bone with which to make the attempt.

Recognising the lesson as previously stated that bone is dominated by muscle, it is scarcely understandable that anatomists should pay so much attention to the minute description of bones, and yet such little regard—as evidenced in any anatomical text book—to the important factor of muscular action, on which the bony changes depend, and which the science of evolution shows us existed before bone had its being.

I beg to thank Dr. Stapley for valued assistance, and the use of material—Mr. Lewis, B.V.S., Research Scholar, ior the photographs, and Mr. Thwaites, M.Sc., for help in the preparations of the dissections, and for some physiological considerations of the functions of the parts concerned.

EXPLANATION OF PLATES LXXVI.-LXXVIII.

Plate LXXVI.

Fig. 1.—Tibia and fibula of Koala (Phascolarctus cinereus).
 „ 2.— „ of Lace lizard or Monitor (Varanus varius).

Plate LXXVII.

Fig. 3.—Tibia and fibula of Kangaroo.
 „ 4.— „ of Sheep.

Plate LXXVIII.

Fig. 5.—Tibia and fibula of Opossum (Trichosurus).
 „ 6.— „ of Agouti (Dasyprocta).
 „ 7.— „ of Hare (Lepus).
 „ 8.— „ of Echidna (Tachyglossus aculeatus).
 „ 9.— „ of Wombat (Phascolomys sp.).

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ART. XXX.—*The Biochemical Significance of Phosphorus.*

BY HILDA KINCAID, M.Sc.

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[Read 10th November, 1910].

The existence of plant life on the earth is essential for the existence of animal life, since plants alone have the power of living entirely on inorganic materials and of building them into the organic substances necessary for the life of animals. Plant life being thus essential, the chemical necessities of plants will determine the chemical necessities of animals.

Of the long list of known chemical elements only comparatively few are of any biological significance. The most important of those which are absolutely essential for plant and therefore for animal life can be put into one or other of two groups.

1. The Water-borne or Soil elements, present in soil or dissolved in rivers or sea-water. To this group belong sodium, potassium, magnesium, calcium, iron, chlorine, sulphur and phosphorus.
2. The Air-borne elements, present in air and in the case of oxygen and nitrogen usually in the free state. To this group belong oxygen, hydrogen, nitrogen and carbon. Since these elements are air-borne there will never be a serious deficiency of them except in rainless areas. On the other hand there is the possibility of deficiency in the soil elements.

Of the soil elements special interest is attached to phosphorus, not only on account of its presence in practically all tissues both animal and vegetable, but also on account of the fact that of all the elements necessary to life it is the one in obtaining which difficulty may be encountered, since in order to be used by the plant it must be in a form available to the

plant. It is an element vastly important in every department of biology, since the nucleoproteins which constitute so large a part of the nucleus of every living cell are rich in phosphorus, and it is also an essential ingredient of lipoid, which recent research has shown to be so important a component of all living tissue. Lilienfeld and Monti discovered phosphorus in bacteria, and analyses of dry bacteria have shown the percentage of P_2O_5 to be greater than that of any other ash constituent (1). For example, in 100 parts of dry substance of Bacillus prodigiosus the total ash = 13.47, K_2O = 1.55, Na_2O = 3.93, CaO = .56, MgO = 1.05, P_2O_5 = 5.12, Cl = .66, NaCl = 1.08, SiO_2 = .07. In 1796 Westrumb demonstrated presence of phosphoric acid in the beer yeast, almost half of the pure ash being phosphoric acid. Yeast placed in a sugar solution bereft of all salts can not bring forth fermentation to any appreciable degree. Mayer placed phosphoric acid in the list of the salts necessary for growth of the yeast plant.

It is a significant fact that all tissues provided for the maintenance of the young are rich in phosphorus. Thus not only eggs and milk, but plant seeds, are rich in this constituent, the percentage of P_2O_5 in the ash of ripe seeds is seldom below 25, and may reach 50 (2). [See analyses of Wolff, Kellner, Lehmann, Presse and Stansell, etc.] Where the phosphorus poor tegument is included in the analysis the results are of course lower. Most of the phosphorus in seeds is in organic combination, such as glycerophosphoric acid or phytovitellinin. The phosphoric acid content in the ash of the underground food reservoirs of the plant is usually markedly lower than in seeds, viz., about 15 per cent., but is very variable. The supply of phosphoric acid has a noteworthy effect on the storing of sugar in storage roots, a rich supply of phosphoric acid causing an increased sugar content in the root (3). Also in the wood of trees, in the sap wood more than in the heartwood, and more in the upper actively growing parts of the tree than in the lower parts; in the bark and in the leaves we find phosphoric acid, in various kinds of combination, as a necessary constituent.

Of essentially animal tissues it forms, in combination with calcium and magnesium, as phosphate, some 85 per cent. of the

bone ash. In muscle the predominating salt is potassium phosphate, the percentage of P_2O_5 in the ash being roughly 35. Brain and nervous tissue are rich in P_2O_5, the ash containing nearly 35 per cent. In lungs and bronchi again the predominating constituent of the ash is phosphoric acid, obtained for the most part from organic combinations (4). The Liver, Spleen, Thymus, also, being rich in cellular elements, have a high percentage of phosphorus in organic combination.

From the time of Liebig attention has been centred on nitrogen as the food element of living things most liable to fluctuation or deficiency; but it must be remembered that nitrogen is in reality air-borne, and an increased demand for this element can be met by increasing the facilities for trapping the air nitrogen. With phosphorus, however, the case is different. It is a constituent of soil or is water-borne, and may be described as the one element about which plants are conservative. Thus it has been shown that the leaves of deciduous trees before being allowed to fall from the plant have practically all the phosphorus extracted from them (5). In much the same way we find animals to be conservative of this element, so that in the young animal where much phosphorus is needed for the growing skeleton the amount excreted is very low. The same is the case during the processes of dentition and lactation.

The widespread distribution of this element in all living things makes it desirable that there should be in soils a large quantity available to plants. That soils may contain a low percentage of available phosphorus is unfortunately well exemplified in many regions of Australia. This lack of phosphorus has been generally recognised for some time, and is indirectly proved by the excellent results following the use of phosphatic fertilisers. Analyses by agricultural experts in the State of Victoria may be found in the Agricultural Journal of Victoria, 1907, comparing the Victorian clay soils with American clay soils. The clay soils are given because they contain a higher percentage of phosphorus than other soils. Thus giving the phosphorus in terms of phosphoric acid, in 100,000 parts of Victorian clay soil we find only 63 parts of phosphoric acid of against 207 parts of phosphoric acid in the same amount of American clay soil. The difference in the sub-soils is not quite

so great, but sufficiently striking to be evident at once; thus per 100,000 parts of clay sub-soil we find in Victoria 66 parts of phosphoric acid as against 159 parts in America. The amount in Mallee soil is very low, namely, 47 parts per 100,000; and American and European authorities look upon 50 parts per 100,000 as the limit below which it is unprofitable to work the soil.

The objects of the following research were:—

1. To ascertain whether plants could accommodate themselves to a soil containing less than the average amount of available phosphorus.
2. To compare the phosphorus content of some typical Australian grown foods with the determinations of phosphorus content in the same kinds of foods in other countries.
3. To determine the distribution and evolutionary significance of phosphorus in muscle, brain, exo- and endoskeleton of animals.
4. To obtain some quantitative data regarding the leakage of phosphorus from Victorian soils.

Methods.

In all the estimations of phosphorus, except where specially mentioned, the method used was a modification of the Neumann method of phosphorus estimation (6), and was as follows:— The substance, weighed in the fresh and then in the dry state, was ashed. The ash weighed and dissolved in a small quantity of nitric acid, diluted, precipitated with 10 per cent. ammonium molybdate in presence of ammonium nitrate, the quantities of these reagents being used in amounts such as are best calculated to prevent precipitation of any molybdic acid, thus when about 10 milligrams of phosphoric anhydride were roughly expected to be present, 4–5 c.c. of strong nitric were used to dissolve the ash, from 150–200 c.c. of water used to dilute, 85 c.c. of 50 per cent. ammonium nitrate added, and the solution then brought almost to boiling point, 50 c.c. of hot 10 per cent. ammonium molybdate were then added, and the solution kept in motion for one minute, then allowed to

stand 15 minutes, when it was then quickly filtered through a Gooch filter, the collected precipitate washed thoroughly with cold water (about six washings), and then dissolved in a known volume of standard sodium hydrate, boiled to expel all the ammonia thus liberated, and when cool the excess of NaOH back titrated with standard acid. The amount of P_2O_5 cal. culated from the number of c.c. of the standard alkali used.

Experimental.

A (1).—Experiments with Fodder Grasses.

To Professor Ewart I am indebted for his kindness in supplying me with samples of 20 fodder grasses; some of them native to Australia, and some of them introduced, but all acclimatised and growing in a wild state free from any artificial manuring.

It was expected that the native grasses accustomed for a long epoch of time to a low supply of phosphorus in the soil would manage with very little of this element, and therefore an analysis would show a low percentage of P_2O_5. On the other hand it was expected that the introduced grasses, accustomed to a fairly high supply of phosphorus, would not show the economy practised by the native grasses with regard to this element, but would show on analysis a higher percentage of P_2O_5, which, however, might be lower than that obtained for the same grasses growing in countries whose soil is not so low in this element. The following table shows the results obtained:—

Percentage of P_2O_5 in Fodders (Dried at 100° C.).
Native and Introduced Grass.

Native.

Name of Grass		% P_2O_5	Mean % P_2O_5
Imperata arundinacea—Lang Lang Grass	(1)	0.1659	0.1680
	(2)	0.1701	
Stipa scabra—Rough Spear Grass - -	(1)	0.1600	0.1543
	(2)	0.1487	
Chloris truncata—Windmill Grass - -	(1)	0.1977	0.2023
	(2)	0.2069	

Name of Grass		% P_2O_5	Mean % P_2O_5
Cynodon dactylon—Couch or Doub Grass	(1)	0.1539	0.1609
	(2)	0.1680	
Microlaena stipoides—Weeping Grass -	(1)	0.1391	0.1330
	(2)	0.1271	
Panicum effusum—Hairy Millet Grass -	(1)	0.0973	0.0988
	(2)	0.1004	
Eragostis pilosa—Lesser Love Grass -	(1)	0.2790	0.2656
	(2)	0.2522	
Danthonia penicillata—Wallaby Grass -	(1)	0.1348	0.1429
	(2)	0.1511	
Poa caespitosa—Tussock Grass - -	(1)	0.1311	0.1350
	(2)	0.1390	
Sporobolus indicus—Ratstail Grass - -	(1)	0.1480	0.1484
	(2)	0.1489	
Anthistira ciliata—Kangaroo Grass -	(1)	0.1258	0.1258
Arundo phragmites—Reed Grass - -	(1)	0.2996	0.2994
	(2)	0.2992	
Introduced.			
Oryzopsis miliacea—Rice Millet - -	(1)	0.3533	0.3880
	(2)	0.4227	
Ehrharta panicea—Panic-like Ehrharta -	(1)	0.3775	0.4124
	(2)	0.4473	
Lolium perenne—Perennial Rye Grass -	(1)	0.3020	0.3160
	(2)	0.3300	
Bromus unioloides—Prairie Grass - -	(1)	0.3646	0.3804
	(2)	0.3962	
Holcus lanatus—Yorkshire Fog Grass -	(1)	0.1427	0.1463
	(2)	0.1500	
Agropyrum repens — English Couch or Quitch Grass - - - - -	(1)	0.1732	0.1608
	(2)	0.1484	
Stenotaphrum Americanum—Buffalo Grass	(1)	0.2791	0.2791
Paspalum distichum—Silt Grass - -	(1)	0.4181	0.4181

The table shows all the native grasses taken, with perhaps the exception of Arundo Phragmites, to have a low percentage of P_2O_5, and all the introduced, with 2 exceptions, viz., Holcus

lanatus and Agropyrum repens, to have a much higher percentage. Of the two exceptions in the list of introduced grasses, it may be said that they can hardly be regarded as fodders at all. They are exceedingly poor grasses whether grown in their native home or in this country, and are frequently regarded as weeds, and weeded out as such. Of the native grass Arundo phragmites it may be noted that it always grows in very wet ground, on the edges of rivers, pools or marshes, which fact may possibly account for its greater percentage of phosphorus, since the tendency of the water, especially if impregnated with CO_2, would be to dissolve phosphate from a considerable depth of soil, and bring it by diffusion into the neighbourhood of the roots, i.e., the water would probably tend to give a larger available supply of P_2O_5 than could be obtained by the dry medium plants.

No record of English or Continental analyses of the particular grasses occurring in the above table could be found; but Balland (7) gives the maximum percentage of P_2O_5 in the fresh millet as .8, which percentage would of course be higher calculated per dry substance, and Wolff (8) in dry millet gives 3.43 per cent. total ash, and in the ash 21.92 per cent. P_2O_5. This calculated to per cent. in the dry substance = about .75. Jordan (9) gives percentage in Timothy Hay .8, and in dry mixed grasses about .5; whilst the highest figure obtained for the grasses analysed in this laboratory = .41, so that we may take it that the introduced fodder grasses have adapted themselves just as the cereals have done[1] to the low-phosphorus soil in which they are placed, but that the adaptation is not complete since they still have a much higher percentage of P_2O_5 than the native grasses.

A (2).—Analyses of the wood of 4 typical Australian trees were also carried out. The trees in question were indigenous, and grew at Warrandyte, Victoria. A section taken right through a bough at the first bifurcation was ashed, and the P_2O_5 determined in the ash.

The following are the mean results of determinations for the per cent. P_2O_5 in the ash:—

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1 *Vide infra.*

Eucalyptus amygdalina or "Messmate"	=	4.456 %
Eucalyptus hemiphloia or "White Box"	=	2.436 %
Eucalyptus haemostoma or "White Gum"	=	2.304 %
Eucalyptus polyanthemus or "Red Box"	=	.856 %

Of these four the messmate is a very quick-growing tree, and is amongst the highest trees of the world. The Red Box, on the other hand, is a slow growing tree, with very hard wood. This difference very likely accounts for the diversity of the P_2O_5 content of the stems of these two, for wherever active growth is going on the P_2O_5 content is higher than in the inactive part, and the actively growing sap wood has always a higher percentage than the hard inactive heart wood.

Czapek (10) gives the percentage of P_2O_5 in the ash of the branch wood of Pinus Silvestris as 11.60; and the percentage in the heart-wood of a beech 220 years old 4.54, and in the sap-wood of the same 13.21; in the heart-wood of an oak 50 years old 5.88, and in the sap-wood 14.28; in the heart-wood of Betula 16.59, and in the sap-wood 13.21. All of these figures are higher than those obtained in the above analyses of the four Australian types taken, which fact again seems to point to an adaptation by plants to a phosphorus-low soil.

A further indication of adaptation is given by Isopogon ceratophyllus, a sample of which was kindly supplied by Dr. Cherry. This is a prickly shrub which only grows in poor soils, and on analysis was found to have an exceedingly low phosphorus content, viz.: 0.033% in the dried substance of the woody stems, and 1.44% in the ash of the same; and 0.046% in the dried substance of the leaves, and 2.09% in the ash of the leaves.

B.—Experiments with some Human Foods.

The extraordinarily wide distribution of phosphorus in the body—in bones, nervous system, all the great gland organs, etc.—makes it an essential ingredient of food. According to Siven (1) the body needs at least .7 to .8 grams daily, and according to Ehrström more than this, viz., 1 to 2 grams daily. Hart, McCollum and Fuller (12) fixed 3 grams of phosphorus per day as the safe minimal quantity for a pig of 50 lbs. weight. The body has a greater power of retaining this

element than any other, in fact the body tries to hold back no other element as energetically as it does phosphorus. It deals with phosphorus in a more economic manner than with nitrogen, for with increased nitrogen intake the body immediately responds by increased nitrogen output to preserve the nitrogen equilibrium. With increased phosphorus intake, however, equilibrium is not established, but some of the phosphorus is retained (11). The amount of phosphorus actually absorbed from the alimentary canal depends on the kind of food—in vegetable foods which contain a large quantity of calcium a good deal of the phosphorus is left behind in the faeces as insoluble calcium phosphate; in meat feeding, on the contrary, most of the phosphorus in the faeces is due to actual intestinal secretion. In the food phosphorus is taken in for the most part in organic combination as nucleoalbumen, nuclein, casein, lecithin, etc., in eggs, milk, leguminous vegetables, and only in small degree in inorganic combination as in grains, and meat.

The experiments of Hart, McCollum and Fuller at the Wisconsin Agricultural Experiment Station (12) show how important is a normal supply of P_2O_5 in food. Animals fed on food deficient in this constituent very soon became abnormal, exhibiting weakness of limbs, langour, debility, and if the experiment continued long enough, finally death; whilst if the diet was made normal again the animals gradually recovered. A disease, allied to rickets, is often found in cattle living on natural foods poor in calcium phosphate. In nearly all cases it is found if phosphates are added to the diet they are quickly absorbed with remedial effect; but a much better effect is gained by the addition to the diet of organic phosphorus combinations than by the addition of only the inorganic salts. The results of the experiments of Le Clerc and Cook (24) seem to point to the fact that organic phosphorus favours nitrogen metabolism, and increases nitrogen and phosphorus retention, especially in the case of a phosphorus poor food.

The researches of Cronheim and Müller (13) on children, and those of Röhmann, Ehrström and Gumpert (25), have shown organic phosphorus feeding to be superior to inorganic for growth and nourishment, and for this reason human milk is

said to be superior to cows' milk, which, though richer than human in total P_2O_5, has yet a lower percentage of organic P_2O_5 ((14) Siegfried).

It is apparently a well-known fact that Australian cereals are lower in phosphorus content than the cereals of other countries; the general figure for wheat varies from 0.65 to 1.11 per cent. P_2O_5 in other countries, whereas 0.5 per cent. is taken as the average figure for Australian wheat; and likewise for oats; which fact points to an adaptation on the part of cereals to phosphorus-poor soils. From a physiological point of view it is the edible flour made from the wheat which is the most important. Experiments were therefore conducted with some local flour to determine whether the total per cent. P_2O_5 be low, and if so whether it be the organic or inorganic which is thus low, or both.

Method.—1. Total P_2O_5 determined in the flour weighed both dry and in the natural state. 2. Alcohol-soluble P_2O_5 determined by extracting the flour with boiling alcohol; exaporating extract, taking up residue with ether, and determining P_2O_5 in the ether residue. It is useless to try to extract with ether alone, for as early as 1891 it was shown by Maxwell (15) that ether would extract only the free lecithin, but would not take up any which was combined with protein.

The mean results obtained were:—

	Total P_2O_5	Alcohol Sol. P_2O_5	P_2O_5 not extractable with alcohol
Per cent. in the undried flour	0.1932	0.0278	0.1654
Per cent. in the dried flour	0.2209	0.0322	0.1887

The results show the total P_2O_5 to be low, and the alcohol soluble moiety to be very small. Since bread is the mainstay and principal foodstuff, particularly of the poorer classes, and of vegetarians, the above fact is of physiological importance. It is very generally recognised by agriculturists that to obtain the best results possible the crops must be well manured by some kind of phosphate manure. If this is not done, and the crop has to depend entirely on the natural supply of phosphates, the entire yield is small, and individual grains poor.

It has therefore unfortunately to be admitted that Australian soils being low in Phosphorus cannot give of this element freely, with the result that plants grown here have to do with a small amount, and therefore consequently animals feeding on these plants obtain likewise a low supply. Remembering how widely distributed this element is in the body, and how conservative the body is of it, and also the results of Hart and McCollum on feeding animals with a low supply, it seems not unwarrantable to suggest the possibility of undesirable physiological features making their appearance as a consequence of this low percentage in one of our chief foods.

A few analyses of eggs were made. The eggs were all obtained from different local sources. The results obtained were:—

EGG 1.

Wt. with shell, grams	60.5696
Wt. edible part, undried, grams	54 3637
Wt. edible part, dried, grams	15.1069
Wt. ash of total edible part	0.5692
Per cent. water in undried edible part	72.2%
Total edible part contains, grams P_2O_5	0.327
Per cent. P_2O_5 in the undried	0.601%
Per cent. P_2O_5 in the dried	2.16%
Per cent. P_2O_5 in the ash	57.49%

EGG 2.

Wt. with shell, grams	59.7355
Wt. edible part, undried, grams	53.0364
Wt. edible part, dried, grams	14.0884
Wt. ash of total edible part	0.543
Per cent. H_2O in the undried edible part	73.4%
Total edible part contains P_2O_5, grams	0.211
Per cent. in the undried	0.39%
Per cent. in the dried	1.500%
Per cent. in the ash	38.89%

EGG 3.

Total edible part contains P_2O_5, grams	0.3307
Per cent. P_2O_5 in the dried	2.45%
Per cent. P_2O_5 in the egg shell	0.0160%

EGG 4.

Total edible part contains P_2O_5, grams	0.3301
Per cent. P_2O_5 in the dry	2.51%
Per cent. P_2O_5 in the shell	0.0226%

EGG 5.

Wt. with shell, grams	52.757
Wt. edible part, undried, grams	45.584
Weight edible part, dried,	12.534
Per cent. H_2O in undried edible part	72.5%
Total edible part egg contains, grams P_2O_5	0·245
Per cent. P_2O_5 in the undried	0.537%
Per cent. P_2O_5 in the dried	1.95%

Balland says (7) an ordinary hen's egg contains about .26 grams phosphorus.

Wolff's (16) analysis of hen's egg without shell gives 73.4 per cent. water, 3.48 per cent. total ash, and per cent. P_2O^5 in the ash 38.05, and in the dried 1.324.

Samples of cows' milk from three different sources were analysed for P_2O_5 content. Results obtained were:—

WILLSMERE MILK.

Sample 1	P_2O_5 in 100 c.c.	0.30354	grams
Sample 2	,, ,, ,,	0.25458	,,
Sample 1	Wt. of 5 ,,	5.0596	,,
Sample 2	,, ,, ,,	6.0354	,,

TALBOT MILK.

Sample 1	P_2O_5 in 100 c.c.	0.21204	,,

PRIVATE DAIRY—KEW.

Sample 1	P_2O_5 in 100 c.c.	0.2040	,,

Bunge (17) says cows' milk contains .181 to .197 grams P_2O_5 in 100 c.c.

König (18) says cows' milk contains .189 grams P_2O_5 in 100 c.c.

Hutchinson (19) says cows' milk contains .220 grams P_2O_5 in 100 c.c.

It is to be noticed that in the case of eggs and milk the figures for the samples analysed here, are not lower than those given in English or German records. This fact is rather interesting, for both are secreted by the parent for the maintenance of the young, and the constituents of such secretions are nearly always kept in amounts such as are best suited for the development of the young; even at the expense of the mother and of the other secretions. When analysing the bones of frogs, it was found that the femur of a female frog, killed just before the breeding season, and containing a mass of small immature ova, contained a very high percentage of P_2O_5, and it is suggested that this might be due to a storing of phosphate in the bone, which could be utilised when the time came for the development of the ova.

Experiments with Meat.—Results of analyses of fresh uncooked undried beef and mutton, practically fat-free, gave percentages of P_2O_5 the mean of which equalled about .38, and calculated to per cent. in the dried meat about 1.8 per cent., figures which agree with those of Francis and Trowbridge (20), but which are a little lower than those of Wolff.

Experiments with Fish.—Analyses of fresh uncooked fish gave mean per cent. P_2O_5 to be .51. This figure also accords well with other analyses. So that as far as the flesh foods go there is little variation in the local examples analysed from those analysed in other countries.

Again the figures for the oysters examined appeared to vary only slightly from the French and Portuguese (21) as far as percentage went, although the total P_2O_5 per oyster is very much smaller in the Australian than the others, owing to their small size. Thus:—

	Australian	French	Portuguese
Average % P_2O_5 in dried oyster -	1.822	1.836	2.052
Average wt. of dried oyster - -	0.548	1.110	1.157
P_2O_5 contained in one average oyster	0.0097	0.020	0.032
Average % P_2O_5 in shell - -	0.0522	0.038	0.089

C.—Experiments to determine the Distribution and Evolutionary Significance of Phosphorus in the Muscular tissue of Animals.

Determinations of the P_2O_5 percentage, in the muscular tissue of various animals, were made. In the case of the Mollusca the adductor muscles from a number of oysters were used for the experiments. In the case of the Arthropoda the body muscles were used. For the Vertebrates the muscles which serve to move the pelvic fin of fishes, and those which move the lower limbs of frogs, lizards, birds, dogs, etc., served as examples for Pisces, Amphibia, Reptilia, Aves, and Mammalia respectively.

The table shows the results:—

P_2O_5 in Muscle—Invertebrates and Vertebrates.

Name	% P_2O_5 in fresh muscle	% P_2O_5 in dried muscle	% P_2O_5 in the ash	% ash in fresh	% ash in dried	Group	
Oyster, Australian (average of 33) - - -	.57	2.69	29.5	1.9	8.9	Mollusca	Invertebrates
Fresh-water "Yabbie" or Astacopsis - - -	,37	2 4	37.93	1.02	6.3	Arthropoda	
Mullet-male - - -	.51	2.22	38.1	1.3	5.8	Pisces	Vertebrates
Bream-female (no roe) -	.51	2.28	42.8	1.2	5.3	„	
Frog (average of adult female and young male)	.42	1.93	35.4	1.2	5.4	Amphibia	
Lizard - - - - -	.41	1.90	36.0	1.2	5 3	Reptilia	
Parrot - - - - -	.47	1.88	38.8	1.2	4.8	Aves	
Thrush - - - - -	.43	1.75	34.5	1.2	5.0	„	
Mouse - - - - -	.34	1.75	33.5	1.2	5.2	Mammalia	
Dog - - - - -	.43	1.90	38.7	1.1	4.9	„	
Cow - - - - -	.38	1·70	36.1	1·0	4.7	„	

It will be obvious from the above table that muscular tissue shows a surprising uniformity in its phosphorus content throughout the animal kingdom. Calculated in the dry substance the figures show the percentage to be slightly greater in the fishes and oysters than in the higher animals, but calculated in the ash the variations show no parallelism with degree of development. We may state therefore that phosphorus of this concentration, viz., .38 to .5, is apparently a normal and essential ingredient for contractile tissue.

D.—Experiments to determine Distribution and Evolutionary Significance in Nerve Substance.

Analyses of brain substance of the various classes of Vertebrates were made. It is unfortunately impossible to get enough nerve tissue for analysis in the Invertebrates.

For results see table p. 383.

The experiments as far as they went show the brain substance in the examples of the various vertebrate classes examined to have practically the same percentage of P_2O_5 in the dried. Thus again in nerve substance there appears to be no parallelism between P_2O_5 content and evolutionary development.

E.—Experiments to determine the Distribution and Evolutionary Significance in the Exoskeleton of Invertebrates.

Analyses of the exoskeletons of Invertebrates, comprising examples from the groups Porifera Coelenterata, Molluscoidea, Echinodermata, Arthropoda and Mollusca were made.

For results see table p. 383.

Per Cent. P_2O_5 in Brain Substance—Vertebrates.

Name	Weight undried	Weight dried	Weight ash	Wt. P_2O_5 in amount taken	% P_2O_5 in fresh	% in the dried	% in the ash	% ash in the fresh	% ash in the dried	Group
Fresh W. Murray Cod (mean of 4)	3.0721	0.43002	0.03612	0.01371	0.446	3.189	37.97	1.17	8.40	Pisces
Sea W. Barracouta (mean of 5)	6.11697	1.18767	0.09145	0.02716	0.444	2.286	29.69	1.49	7.70	Pisces
Frog (mean of 4)	1.3000	0.10977	0.0130	0.00353	0.270	2.29	27.15	1.00	11.1	Amphibia
Rooster (mean of 2)	4.9886	0.94798	0.06747	0.03099	0.420	2.21	31.33	1.33	7.11	Aves
Turkey	2.87619	0.55619	0.03851	0.01480	0.514	2.66	38.90	1.32	6.92	Aves
Rabbit	6.2525	1.41454	0.09970	0.03149	0.503	2.226	31.58	1.59	7.05	Mammalia
Sheep	5.3299	1.00322	0.07354	0.02911	0.546	2.902	39.90	1.37	7.33	Mammalia

P_2O_5 in Exoskeleton of Invertebrates.

Name	Weight taken undried	Weight dried	Weight ash	Wt. P_2O_5 in amount taken	% P_2O_5 in the undried	% P_2O_5 in the dried	% P_2O_5 in the ash	% ash in the undried	% ash in the dried	Group
Sponge	—	—	—	trace	trace	trace	trace	—	—	Porifera
Hydrozoa Zoophytes	—	—	—	trace	trace	trace	trace	—	—	Coelenterata
Coral 1	—	2.2902	1.70410	trace	trace	trace	trace	—	74.4	Coelenterata
Coral 2	—	2.7572	2.3497	trace	trace	trace	trace	—	85.2	Coelenterata
Polyzoon	—	0.10168	0.04420	trace	trace	trace	trace	—	43.47	Molluscoidea
Starfish 1	1.5950	1.29421	0.54882	0.00338	0.2121	0.261	0.615	34.40	42.4	Echinodermata
Starfish 2	2.1160	1.47725	0.70759	0.00453	0.2140	0.306	0.640	33.4	47.0	Echinodermata
Astacopsis or Fresh W. Yabbie 1	—	0.66523	0.28273	0.021102	—	3.17	7.14	—	42.5	Arthropoda
" " " 2	—	1.4981	0.46831	0.04763	—	3.17	10.17	—	31.26	Arthropoda
" " " 3	—	1.2293	0.36063	0.03431	—	2.79	9.51	—	29.33	Arthropoda
Sea W. Cray 1	—	1.49959	0.66553	0.01303	—	0.869	1.95	—	44.39	Arthropoda
" 2	—	1.7541	0.70995	0.02096	—	1.194	2.95	—	40.47	Arthropoda
Oyster 1	43.3948	42.1284	—	0.0184	0.0424	0.0436	—	—	—	Mollusca
" 2	34.1714	33.13465	—	0.02017	0.0590	0.0608	—	—	—	Mollusca
Cuttle-fish 1	1.4100	1.37314	0.8589	0.0023	0.1631	0.1670	0.265	60.92	62.5	Mollusca
" 2	1.9351	1.8834	1.30988	0.0034	0.1700	0.1800	0.258	67.69	69.5	Mollusca

The results show several interesting features:—

1. Taking the class Invertebrata as a whole it will be apparent from the table that the protective or skeletal tissues derive their physical properties of rigidity, etc., from mineral matter other than phosphate, the latter only being present in small amount; the chief mineral salt being calcium carbonate. When a tissue is composed largely of calcium carbonate, this salt is invariably crystalline, and in consequence the tissue is brittle. Calcium phosphate on the other hand is capable of existing in a colloidal form, which does not render a tissue brittle. Apparently then the Invertebrates as a whole have not learned to avail themselves to any extent of colloidal calcium phosphate in the construction of their protective tissues; thus whilst they are rigid they are at the same time easily broken.

2. Taking the individual groups of the Invertebrata it is most interesting to note an increase in the P_2O_5 content of the exoskeleton as we ascend the evolutionary scale. Thus the Sponges, the Hydrozoa, the Corals, and the Polyzoa, have merely a trace of P_2O_5 as evidenced by a yellow coloration and a faint haze of precipitate with ammonium molybdate and nitric acid. Then the Starfish has a measurable quantity—.26–.30 per cent. In the group Arthropoda we find a marked rise, particularly in the fresh-water "yabbie" or Astacopsis, but not so marked in the salt-water crayfish, falling again to a low percentage in the oyster shell and cuttle fish of the next group, Mollusca. Some authors, however, would give the Arthropoda a higher place than the Mollusca, in evolution, and in regard to the utilisation of phosphorus in the exoskeleton they are certainly further on than Mollusca.

F.—Experiments to determine the Distribution and Evolutionary significance of Phosphorus in the Endoskeleton of the Vertebrates.

In all the experiments in this section the bone analysed was the femur or that most comparable to the femur; thus in fishes the bone supporting the pelvic fin was the one used.

Results follow in tabular form:—

P_2O_5 IN ENDOSKELETON OF VERTEBRATES.

Name	Weight of fresh bone	Weight of dried bone	Weight of ash	Wt. P_2O_5 in bone taken	% P_2O_5 in the fresh	% P_2O_5 in dried bone	% in ash	% ash in the fresh bone	% ash in dried bone	Group
Shark 1 (female)	1.5950	0.41157	0.11364	0.0365	2.28	8.87	32.13	7.12	27.61	Pisces (Elasmobranchii)
,, 2 (female)	1.8705	0.50578	0.14307	0.0453	2.42	8.97	31.72	7.64	28.28	
Fresh W, Murray Cod	0.1520	0.08474	0.04095	0.0173	11.43	20.51	42.5	26.9	48.33	Pisces (Teleostei)
Sea W. Barracouta	0.0900	0.06485	0.03125	0.0136	15.20	21.11	43.8	34.7	48.20	
Mullet 1 (male)	0.05121	0.04044	0.02131	0.0091	17.87	22.63	42.96	41.61	52.69	
,, 2 (female)	0.05691	0.04692	0.02570	0.0109	19.24	23.34	42.62	45.15	54.70	
Perch 1	0.0835	0.07062	—	0.0205	24.57	29.06	—	—	—	
,, 2	0.0945	0.07884	—	0.0220	23.32	27.99	—	—	—	
Frog 1 (male)	0.06626	0.05338	0.02586	0.0107	16.27	20.20	41.69	39.00	48.4	Amphibia
,, 2 ,,	0.10232	0.06534	0.04399	0.0182	17.86	27.98	41.56	42.9	67.3	
,, 3 ,,	—	—	—	—	19.84	25.15	—	—	—	
,, 4 ,,	0.0765	0.06130	0.03044	0.0127	16.90	20.80	41.9	40.3	49.6	
,, 5 ,,	0.0747	0.0511	0.0267	0.0113	15.21	22.24	44.23	32.9	50.2	
,, 6 (female not breeding season)	0.0870	0.06245	0.03518	0.0142	16.35	22.8	40.4	40.4	56.3	
,, 7 ,, early ,, ,,	Weights mislaid in this case					37.40				
Toad (male)	0.0744	0.0544	—	0.0177	23.78	32.56	—	—	—	
Turtle	1.0915	0.9284	0.5262	0.2031	18.76	21.88	38.60	48.2	56.5	Reptilia
Lizard	0.2862	0.22761	0.13370	0.0531	18.15	23.35	39.8	46.7	58.7	
Parrot	0.1765	0.12683	0.06698	0.0261	14.80	20.61	39.03	37.9	52.7	Aves
Thrush	0.1394	0.09800	0.05089	0.0207	14.90	21.20	40.83	36.5	51.9	
Sparrow 1 (female)	0.0700	0.05559	0.02456	0.0107	15.30	19.3	43.9	35.0	53.7	
,, 2 ,,	0.0640	0.04798	0.02040	0.0083	13.08	17.4	41.04	31.8	42.5	
Echidna 1	—	—	—	—	15.86	21.60	—	—	—	Mammalia
,, 2	—	—	—	—	16.78	22.85	—	—	—	
Mouse 1	0.0690	0.0436	0.02457	0.0119	17.29	27.37	48.57	35.60	56.35	
,, 2	0.0557	0.04202	0.02343	0.0121	21.79	28.89	51.82	42.06	55.78	
Rabbit 1 (male)	7.0310	4.86306	2.70849	1.1297	16.06	23.23	41.71	38.5	55.7	
,, 2 ,,	5.6950	4.4346	2.26077	0.9277	15.90	20.90	41.40	39.6	50.9	
Cat (female)	9.7100	5.7746	—	1.4930	15.30	25.85	—	—	—	
Dog (female)	41.3300	25.6244	—	6.3316	15.31	24.70	—	—	—	
Sheep	134.080	118.4150	47.3349	20.697	15.43	17.47	43.72	35.3	39.9	

In this table, as in the preceding one, several interesting points should be noted:—

1. A marked difference between the magnitude of the P_2O_5 content of the skeleton of the Vertebrates and Invertebrates. Thus even in the shark where cartilage takes the place of true bone there is a sudden and unmistakable rise from the percentage in even the highest group of the Invertebrates; the metapterygium of the shark (a fairly young female) giving 32 per cent. P_2O_5 in the ash, and about 8.9 per cent. in the dried.

2. Tracing up the ascending groups of the Vertebrata, we find a marked rise from the cartilaginous to the bony fishes; but from there right on through amphibia, aves and mammalia, there is no very great variation, at any rate in the percentage value in the ash.

The cartilaginous fishes seem to stand in this respect midway between the main body of the Invertebrates on the one hand, and of the Vertebrates on the other—the Invertebrates, which have not yet learned the knack to any extent of utilising phosphorus in the skeleton, and the Vertebrates which have apparently early learned (even as early as the fishes) to utilise this element, and learned moreover to use it in amount best suited to the requirements, since from the fishes right on through the higher groups there is scarcely any variation; any small variations which do occur might easily be due to differences in food and environment. Although calcium phosphate is much superior to calcium carbonate, in that it can be kept much more readily in colloidal form than the carbonate can, and the characteristic rigidity and elasticity of bone can be maintained; yet this colloidal calcium phosphate is very unstable and constantly tends to slip into the crystalline form. The theory may be put forward that in the bones of animals this crystalline form is at once removed by the blood, and excreted as quickly as it is formed, and fresh colloidal phosphate takes its place, and thus is explained the necessity for metabolism in bone. In old age the replacement of the crystalline by colloidal is less efficient, and hence the bones become brittle.

G.—Phosphorus in Australia from an Economic View Point.

At the beginning of this paper it was pointed out that Australian soils as a whole are very low in phosphorus content, but

especially the superficial soils. Whether or no the total P_2O_5 in superficial soils plus sub-strata and sub-sub-strata, could we go deep enough, would be found to be lower than other countries it is hard to say, and the knowledge would be well nigh useless even were it possible. It is the available phosphorus which is the important thing, and if the available amount be small it matters little how large the inaccessible amount may be. In an extremely interesting paper (22) Dr. Cherry gives some possible causes for this deficiency. He points out the cycle by means of which inorganic rock phosphate fairly deep in the ground becomes converted into inorganic bone phosphate, and finally laid down superficially on the ground. The deep ground phosphate is dissolved by the acid juices of plant roots, absorbed and assimilated, becoming part of the plant substance. The plant will be either eaten by an animal and its phosphoric acid concentrated in the bony framework of the animal, which in the natural course of events will eventually die, and its skeleton after the organic matter has become oxidised be left deposited on the ground as superficial, easily-available phosphate; or else the plant untouched will also in time die, and a large amount of phosphorus stored in the leaves, fruit, bark and wood will be deposited superficially.

Since animals feed on plants there must of necessity be a continual struggle for survival, so that the larger and more numerous the animals are in any place, the greater will be the plant growth to keep pace, and consequently the roots will penetrate deeper into the earth and amongst other things a larger amount of phosphoric acid, hitherto deep buried and non-available, will become superficial and easily available. The low percentage of phosphoric acid in Australian soils is attributed by Dr. Cherry to the fact that Australia has never had any large land animals. Certainly there have been discovered near Lake Eyre, South Australia, areas of phosphate deposit, but these are probably due to crocodile fossils, and not to land animals.

Let us now view the state of affairs at the present day. Australia has opened out largely as a grazing country. This opening out has had two effects:—

1. The diminution in the number of native animals which were left in the olden times to die on the land and render up their phosphorus.

2. The introduction of a vast number of animals—viz., sheep, cattle, pigs, etc., which resemble the native animals of the olden time in that they convert plant-phosphorus into bone phosphorus, but which differ in this, that they are not left to die on the land, but to a large extent are exported, bones and all, right out of the country, carrying a large quantity of our much needed phosphorus.

In the past year Victoria alone is estimated to have carried some 12,500,000 sheep and lambs, besides cattle (23). If these sheep died on the land they would be helping on the cycle from deep to superficial phosphate. Of these 12,500,000 grazing, over three million are slaughtered, about 800,000 being exported, and the rest used for home consumption. The phosphorus in the faeces represents nearly all that which is returned to the land, only a small proportion of the sheep carried dying on the land except in a season of drought. The use of phosphatic manures has increased largely within the last few years, with advanced scientific knowledge and improved methods, but as yet it is largely the cultivated land which is benefited, and comparatively little the grazing land. It is interesting to get some approximate valuation of the phosphoric acid represented by 3,309,865 sheep—the number slaughtered. On an average the amount of phosphoric acid in the carcase of one sheep would be roughly 2.5 to 3 lbs. This gives an approximate estimate of 3699 tons of phosphoric acid taken from the grazing land by 3,309,865 sheep; of which about 892 tons are entirely lost to the State by the export of 800,000 sheep. A very considerable amount. The amount lost by beef is much less than by mutton; about 279,710 oxen being slaughtered for food per year, the average weight of a carcase being from 750 to 800 lbs., and amount H_3Po_4 in the carcase about 2 per cent., giving a loss of 1872 tons, about, from the grazing land; the amount entirely lost from the State in this way being only about 15 tons, since only 168,294 lbs. of beef are exported.

The Victorian Year Book, 1908-9 (23), shows the grand total number of pairs of frozen rabbits and hares exported oversea

from years 1902 to 1908, inclusive, to be no less than 25,416,445. These large figures suggested that this one export alone might be responsible for quite a considerable loss of phosphoric acid. Some typical export rabbits were secured; weighed fresh, dried in the oven at 100 degrees C., and then weighed again; the dried flesh separated from the bones and ground to a powder; the whole of it weighed, and an aliquot part taken and oxidised with boiling strong acids. The P_2O_5 precipitated as ammonium phospho-molybdate, redissolved, reprecipitated with magnesia mixture, filtered, washed, dried, ignited and weighed as pyrophosphate. The bones were treated in much the same way, dried and weighed. A little trouble was experienced in getting a homogeneous mixture, since the bones could not easily be ground to a powder as was the flesh. The difficulty was got over by wrapping them in a cloth to prevent any loss of flying particles, and crushing them with a heavy hammer so fine that the mixture could be taken as homogeneous. Results of experiments conducted in this way showed the amount of H_3PO_4 per total rabbit to be about 29 grammes, or 2.7 per cent. Taking the figures given above this makes an export of about 3,362,037 lbs., or 1500 tons of phosphoric acid in the rabbits exported during those seven years, or taking average for one year. 214 tons. Looked at in this light the rabbit appears not only a pest responsible for a good deal of damage to the pastoralist in an ordinary way, but also a pest which is constantly ridding land of valuable constituents. Of course, besides those used for export and home consumption, there are great numbers still left to die on the land; but these fail to be of much service by dying in their burrows, most of which are in low grazing land, and deep enough to be below the general level reached by plant roots. Having found that Victoria loses so much by her large export of mutton, and so much by an almost incidental export of a pest, we naturally turn to the large export—wool. Samples of export wool were obtained[1]; weighed just as they were obtained; oxidised with acid, and the phosphoric acid determined in the same way as in the rabbit. The first experiments showed that the percentage of phosphoric acid in wool is low, and large

1 I here acknowledge my indebtedness to Dr. W. P. Norris for his kindness in securing samples of wool and export rabbits.

quantities of wool, therefore, had to be used in the estimations. Mean of experiments gave the percentage to be .0220. It is only the large amount of wool exported which makes the phosphoric acid lost in this way at all appreciable. For the year 1908-9 (23) the production of wool is given as 87,536,450 lbs., almost the whole of this being exported.

This gives the phosphoric acid lost in this way as 19,258 lbs., or about 8½ tons.

From the cultivated land the chief loss is by wheat. In year 1908-9 (23) the total wheat production in Victoria was 23,000,000 bushels, about 2,000,000 bushels of which were returned to the land as seed, 21,000,000 bushels being thus lost to the cultivated land, and of those about 15,000,000 exported. The average percentage of phosphoric acid is about .5, in Australian wheat. The amount of phosphoric acid therefore lost to the cultivated land = 2929 tons and lost entirely to the State = 2097 tons.

Summarising these results:—

A.—Lost from Victorian Grass Lands per year.

			Lost from State.
1. By Mutton	- -	3699 tons	-	892 tons
2. By Rabbits	- -	214 ,,	-	214 ,,
3. By Beef	- -	1872 ,,	-	15 ,,
4. By Wool	- -	8½ ,,	-	8½ ,,
		5793½ tons		1129½ tons

B.—Lost from Cultivated Land.

				Lost from State.
1. By Wheat	- -	2929 tons	-	2097 tons

When we remember this is in terms of pure phosphoric acid and not in terms of commercial manures (which usually only contain from 20-24 per cent. of H_3PO_4), and also in this list no account is taken of condensed milk, bacon, ham, cheese, etc., we cannot but realise the necessity for fertilising the land to make up for this continuous drainage. That this is made up to a very large extent on cultivated land is admitted, but the above figures show that the grass lands are submitted to a heavy leakage, and this has been going on, uninterrupted, more

or less steadily, ever since the country has been used for pasture; hence need to impress the necessity of returning to the grazing lands the essential element which thy have been gradually losing for so long.

Conclusions.

1. The phosphorus content of the muscular tissue of all classes of animals is practically a constant.

2. The phosphorus content of the nervous tissue of all classes of Vertebrates is likewise practically a constant.

3. The phosphorus content of the exoskeleton of all Invertebrates is low, but is considerably greater in the higher groups than in the lower.

4. The phosphorus content of the endoskeleton of all Vertebrates is much higher than in the exoskeleton of Invertebrates, and varies very little in the different classes except that it is lower in the cartilaginous fishes.

5. Australian native grasses have a markedly lower phosphorus content than European.

6. Acclimatised European grasses have a higher phosphorus content than native Australian, but lower than the same kinds of grasses grown in Europe.

7. The wood of Australian trees has a lower phosphorus content than that of European trees.

8. The total phosphorus content of Victorian flour is low, and the alcohol soluble moiety particularly low.

9. The phosphorus content of Victorian eggs, milk and flesh foods does not vary appreciably from European.

10. The loss of phosphorus per year from Victorian grass lands, by export of their products, is considerable, and it is a matter of economic importance that the phosphorus thus abstracted should be returned.

I wish very much to express my indebtedness to Professor Osborne, in whose laboratory this research was conducted, and to thank him for his continued interest and assistance.

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Art. XXXI.—*Longevity of Seeds and Structure and Nature of Seed Coat.*

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Government Research Bursar.

(With Plates LXXIX.-LXXXI.).

[Read 8th December, 1910].

The subject for this paper was suggested to me by Professor Ewart some time after the publication of his work on Longevity of Seeds.[1] From his experiments he found that the majority of macrobiotic seeds belong to the order Leguminosae, and that the highest percentage of germination occurs among the so-called "hard" seeds, which require soaking in sulphuric acid or other treatment to make them swell up in water. In the appendix to the same paper Dr. White showed that the hardness is almost invariably due to the presence of a distinct cuticle of varying thickness. In the small seeds the cuticle alone seems to confer impermeability, but in the larger types the palisade cells are also responsible.

As a large number of the hard seeds are of economic value, it is advisable to devise some convenient method of softening them, and, further, the method must be such as will have no detrimental effect on the germination. This work includes also records of a number of tests made for the purpose of ascertaining the lengths of time during which various seeds retain their power of germinating. This part is merely a few supplementary records to those made and compiled by Prof. Ewart in 1908.

The work has been carried out in the Botanical Laboratory of the Melbourne University under the supervision of Professor Ewart, to whom I wish to express my thanks for his assistance and untiring interest. I take the opportunity of thanking Mr. H. Pye, of the Dookie Agricultural College, and the Agricultural Department, for supplies of seeds through the National Herbarium, Melbourne.

1 Proc. Roy. Soc. Victoria, vol. xxi., pt. i. (1908).

Longevity of Seeds.

After the publication of the above-mentioned paper on "Longevity of Seeds," an additional set of seeds, all over 16 years old, was received by Professor Ewart and passed on to me to be tested. I used in addition a number of seeds sent from time to time from the National Herbarium, Melbourne. These seeds varied in age from one to fifty-nine years.*

The above seeds had all been stored in packages, and were in a clean, dry condition. In one instance only, *Albizzia lophantha*, had the seeds remained in the soil. They were gathered from ground which had been cleared of the trees in 1887, so the seeds were at least 23 years old, and the majority were probably much older.

The method of testing the seeds was that found to be most satisfactory by Prof. Ewart in his work. The seeds were counted (one hundred being used for each test whenever material permitted), sown on moist blotting paper in small glass vessels, and kept in a germination chamber at 30 deg. C. The material was inspected constantly, growth of mould and attacks of bacteria being prevented by frequent washing and renewing of the blotting paper.

In the case of samples containing hard seeds, the following method was employed. Those seeds which swelled in water were removed, and their percentage of germination noted, the remaining hard seeds were treated with sulphuric acid to remove the cuticle; the duration of the treatment depending on the resistance of the coat. The seeds were placed in strong sulphuric acid for a certain time, then washed repeatedly in water and finally with dilute ammonia to remove all traces of acid. The number of seeds which swelled after each treatment, and their percentage of germination, were recorded in the list.

The following list is a record of all the seeds tested. The name appears in the first column, the age of the seed in the second, the number of seeds used for the test in the third, the percentage of germination in the fourth, and in the fifth is noted the method of treatment. Where the name is marked with an asterisk all the observations are from the same sample of seed.

* Through the kindness of Prof. Vines a sample of the seed of an unnamed *Acacia* sent to Sir John Herschel, in 1843, was received for testing. Possibly owing to the smallness of the sample none of the seeds proved to be germinable, for within the past three or four years, Prof. Vines informs me, Sir William Herschel was able to raise a few short lived seedlings from the same seed.

	Years old.	No. of Seeds.	Per cent. germ.	
Abies amabilis, Forb.	16	50	nil	Sw. water.
*Abrus precatorius, L.	over 14	11	nil	Sw. water.
ditto	over 14	4	nil	Sw. after 1 hr. in acid.
*Acacia acinacea, Lindl.	40	49	nil	Sw. water.
ditto	40	11	55	Filed to cause swelling in water.
*Acacia decurrens, Willd.	16	8	25	Sw. water.
ditto	16	48	85	Sw. after 2 hrs. in acid.
ditto	16	18	22	Sw. after $3\frac{1}{2}$ hrs. in acid.
ditto	16	19	95	Sw. after $5\frac{1}{2}$ hrs. in acid.
ditto	16	5	100	Sw. after $8\frac{1}{2}$ hrs. in acid.
ditto	16	1	100	Sw. after $8\frac{1}{2}$ hrs. in acid, and subsequent
*Acacia melanoxylon, R. Br.	16	22	9	filing.
ditto	16	26	8	Sw. water.
ditto	16	40	46	Sw. after 1 hr. in acid.
ditto	16	10	33	Sw. after 2 hrs. in acid.
ditto	16	2	50	Sw. after $3\frac{1}{2}$ hrs. in acid.
*Acacia Oswaldi, F.V.M.	16	12	nil	Sw. after $6\frac{1}{2}$ hrs. in acid.
ditto	16	2	50	Sw. water.
*Acacia pycnantha, Benth.	16	7	nil	Sw. after 2 hrs. in acid.
ditto	16	26	23	Sw. water.
ditto	16	51	80	Sw. after 2 hrs. in acid.
ditto	16	13	62	Sw. after $3\frac{1}{2}$ hrs. in acid.
ditto	16	3	100	Sw. after $5\frac{1}{2}$ hrs. in acid.
Negundo aceroides, Moench.	16	54	nil	Sw. after $8\frac{1}{2}$ hrs. in acid.
(Acer negundo, L.)	16	100	nil	Sw. water.
Acer rubrum, L.	23—	2	100	Sw. water.

* All from the same sample.

	Years old.	No. of Seeds.	Per cent. Germ.	
*Albizzia (Acacia), lophantha, Benth.	23—	3	100	Sw. water.
ditto	23—	2	100	Sw. after 1 hr. in acid.†
ditto	23—	1	100	Sw. after 5 hrs. in acid.
ditto	23—	18	100	Sw. after 7 hrs. in acid.
ditto	23—	22	100	Sw. after 12 hrs. in acid.
ditto	23—	38	100	Sw. after 18 hrs. in acid.
ditto	23—	2	100	Sw. after 40 hrs. in acid.
ditto	23—	1	100	Sw. after 43 hrs. in acid.
ditto	23—	2	100	Sw. after 45 hrs. in acid.
ditto	23—	3	100	Sw. after 48 hrs. in acid.
ditto	23—	5	100	Sw. after 70 hrs. in acid.
ditto	23—	1	100	Sw. after 84 hrs. in acid.
ditto	23—	3	100	Sw. after 93 hrs. in acid.
*Albizzia lophantha, Benth.	23—	41	100	Sw. water.‡
ditto	23—	5	100	Sw. after 7½ hrs. in acid.
ditto	23—	1	100	Sw. after 8½ hrs. in acid.
ditto	40	15	nil	Sw. after 10½ hrs. in acid.
Althaea narbonnensis, Power	16	100	nil	Sw. water.
Angophora subvelutina, F.V.M.	16	11	nil	Sw. water.
Atriplex spongiosa, F.V.M.	4	100	38	Sw. water.
Avena pratensis, L.	4	100	25	Sw. water.
ditto	6	100	64	Sw. water.
ditto	6	100	37	Sw. water.
ditto	7	100	48	Sw. water.
ditto	5	100	46	Sw. water.

* All from the same sample.
† Temperature 11 deg. C.
‡ Temperature 30 deg. C.

	Years old.	No. of Seeds.	Per cent. Germ.	
ditto	5	100	33	Sw. water.
ditto	6	100	6	Sw. water.
ditto	15	20	nil	Sw. water.
Bauhinia acuminata, L.	16	200	nil	Sw. water.
Betula alba, L.	50	100	nil	Sw. water.
Brassica alba, Boiss.	21	5	nil	Sw. water.
Butea frondosa, Roxb.	14	25	nil	Sw. water.
Cajanus indicus, Spreng.	11	100	nil	Sw. water.
Callitris, rhomboidea, R. Br.	29	100	nil	Sw. water.
ditto	13	82	nil	Sw. water.
Callitris Muelleri, Bth. and Hook, f.	21	44	nil	Sw. water.
Callitris, robusta, R. Br.	30	100	nil	Sw. water.
ditto	12	70	nil	Sw. water.
ditto	59	100	nil	Sw. water.
Carex Pseudo-cyperus, L.	43	32	nil	Sw. water.
*Cassia glauca, Lam.	43	50	10	Sw. water.
ditto	43	10	10	Sw. after ½ hr. in acid.
ditto	43	4	85	Sw. after 1 hr. in acid.
ditto	43	1	100	Sw. after 2 hrs. in acid.
ditto	16	34	nil	Sw. after 3 hrs. in acid.
Catalpa bignonioides, Walt.	16	50	nil	Sw. water.
Catalpa speciosa, Warder	16	95	nil	Sw. water.
Cedrela Toona, Roxb.	16	14	nil	Sw. water.
Celtis australis, L.	14	6	nil	Sw. water.
Ceratonia Siliqua, L.	14	19	nil	Sw. water.
ditto	43	100	nil	Filed.

* All from the same sample.

	Years old.	No. of Seeds.	Per cent. Germ.	
Chenopodium album, L.	33	100	nil	Sw. water.
Chenopodium chilense, Schrad.	59	50	nil	Sw. water.
Crepis foetida, L.	16	100	nil	Sw. water.
Cupressus sempervirens, L.	14	94	nil	Sw. water.
Cytisus canariensis, Steud.	14	6	50	Sw. water.
ditto	17	50	46	Filed.
Dodonaea viscosa, Jacq.	17	50	24	Sw. water.
Dolichos biflorus, L. (white var.)	15	50	nil	Sw. water.
Duranta plumieri, Jacq.	20	25	nil	Sw. water.
Erythrina indica, Lam.	15	7	43	Sw. water.
ditto	21	50	nil	Sw. water.
Erythrina speciosa, Andr.	16	50	8	Sw. water.
Eucalyptus Baileyana, F.v.M.	16	100	1	Sw. water.
Eucalyptus botryoides, Sm.	16	50	30	Sw. water.
Eucalyptus calophylla, R. Br.	16	100	14	Sw. water.
Eucalyptus corynocalyx, F.v.M.	16	100	68	Sw. water.
Eucalyptus diversicolor, F.v.M.	16	100	3	Sw. water.
Eucalyptus Maideni F.v.M.	3	50	82	Sw. water.
Eucalytpus miniata, A. Cunn.	16	100	1	Sw. water.
Euchlaena mexicana, Schrad.	15	50	nil	Absorbed water but remained hard for many weeks.
Euphorbia eremophila, A. Cunn.	10	100	nil	Sw. water.
Exocarpus	16	34	nil	Sw. water.
Fatsia japonica, Deene and Planch.	1	100	nil	Sw. water.
Foeniculum vulgare, Mill.	15	100	nil	Sw. water.
ditto	15	100	nil	Sw. water.
ditto	14	100	nil	Sw. water.

	Years old.	No. of Seeds.	Per cent. Germ.	
Fraxinus americana, L.	16	37	nil	Sw. water.
Fraxinus pubescens, Lam.	16	37	nil	Sw. water.
Fraxinus sambucifolia, Lam.	16	18	nil	Sw. water.
Fraxinus viridis, Bosc.	16	33	nil	Sw. water.
Gleditschia sinensis, Lam.	40	9	nil	Sw. water.
*Gleditschia triacanthos	40	2	nil	Sw. water.
	40	8	nil	Filed.
Gomortega nitida, Ruiz and Pav.	2	4	nil	Very hard outer covering, water took long time to penetrate.
Heterodendrum oleaefolium, Desf.	11	25	nil	Sw. water.
Hieracium stiriacum, Kern.	30	50	nil	Sw. water.
Hordeum (sativum), vulgare, L.	6	100	nil	Sw. water.
ditto	6	100	86	Sw. water.
ditto	38	25	nil	Sw. water.
ditto	6	100	3	Sw. water.
ditto	4	100	55	Sw. water.
Hypericum Androsaemum, L.	27	100	nil	Sw. water.
Juniperus bermudiana, L.	13	50	nil	Sw. water.
Juniperinus flaccida, Schlecht.	15	15	nil	Sw. water.
Kentrophyllum lanatum, L.	44	100	nil	Sw. water.
Ligustrum Stauntoni, D.C.	15	25	nil	Sw. water.
Linum (monadelphum), usitatissimum, L.	42	100	nil	Sw. water.
Liriodendron tulipifera, L.	16	16	nil	Sw. water.
Lychnis coronaria, Desr.	43	100	nil	Sw. water.
Lychnis Githago, Scop.	43	100	nil	Sw. water.

* All from the same sample.

	Years old.	No. of Seeds.	Per cent. Germ.	
Marsdenia Leichardtiana, F.v.M.	13	50	nil	Sw. water.
Melia Azedarach, L.	20	100	nil	Sw. water.
Mucuna nivea, D. C.	15	6	nil	Sw. water.
Nelumbium speciosum, Willd.	13	2	nil	Sw. water.
Nicotiana glauca, R. Grah.	16	100	nil	Sw. water.
Panax elegans, C. Moore and F.v.M.	16	100	nil	Sw. water.
Panicum miliaceum, L.	16	100	nil	Sw. water.
ditto	16	100	nil	Sw. water.
Pastinaca sativa, L.	5	100	nil	Sw. water.
Phalaris canariensis, L.	15	100	nil	Sw. water.
Phaseolus Mungo, L.	14	100	17	Sw. water.
ditto	14	100	48	Sw. water.
Ranunculus bulbosus, L.	18	50	nil	Sw. water.
Raphanus sativus, L.	15	100	nil	Sw. water.
Ricinus communis, L.	3	19	47	Sw. water.
Sapindus (emarginatus), trifoliatus, L.	20	25	nil	Sw. water.
Saponaria Vaccaria, L.	20	25	nil	Sw. water.
Sequoia sempervirens, Endl.	16	100	nil	Sw. water.
Sequoia gigantea, Lindl. and Gord.	16	100	nil	Sw. water.
Sorghum sp. ?	16	100	5	Sw. water.
Sorghum sp. ?	16	100	nil	Sw. water.
Sorghum sp. (?)	16	100	15	Sw. water.
Spergula arvensis, L.	31	12	nil	Sw. water.
ditto	14	100	3	Sw. water.
Spergularia rubra, J. and C. Presl.	14	25	52	Sw. water.

	Years old.	No. of Seeds.	Per cent Germ.	
Sterculia, sp. ?	16	100	nil	Sw. water.
*Swainsona monticola, Benth.	18	61	nil	Sw. water.
ditto	18	39	59	Filed to produce swelling.
Syncarpia laurifolia, Tenore	16	60	70	Sw. water (used selected sample of well developed seeds).
Tristania conferta, R. Br.	16	100	nil	Sw. water.
Triticum vulgare, Vill.	13	100	nil	Sw. water.
ditto	6	100	nil	Sw. water
ditto	9	100	nil	Sw. water
ditto	10	100	nil	Sw. water.
ditto	8	100	5	Sw. water.
ditto	7	100	nil	Sw. water.
ditto	2	100	nil	Sw. water, withered grains
ditto	9	100	3	Sw. water.
ditto	5	100	19	Sw. water
ditto	4	100	72	Sw. water.
ditto	3	100	nil	Sw. water.
ditto	5	100	52	Sw. water.
ditto	12	100	nil	Sw. water.
ditto	14	100	nil	Sw. water.
ditto	15	100	nil	Sw. water.
ditto	9	100	5	Sw. water.
ditto	6	100	92	Sw. water.
ditto	9	100	nil	Sw. water.
ditto	11	100	nil	Sw. water.
Tunica prolifera, Scop.	8	25	4	Sw. water.

* All from the same sample.

Structure of Seed Coat and Resistance to Water.

As has been already mentioned in the introduction to this paper, Dr. White examined more than 60 kinds of hard seeds, and found that in every case the seed was covered by a cuticle which rendered it impermeable to water. This cuticle stained brown with chlor-zinc-iodine.

In this work I have examined an additional number of seeds, and have selected six kinds, the seed coats of which differ somewhat in structure. These have been used throughout as types and subjected to various treatments, in order to determine the detailed microscopical structure of the impermeable coat or coats, the nature and distribution of the impregnating substances, and the character of the material forming the basis of the cuticularised walls. In each case a large number of seeds were soaked in water for forty-eight hours, and all those which remained unswollen after that time were picked out and set aside for further treatment. In the first place hand sections of the seed coats were cut and stained on the slide with chor-zinc-iodine, and in this way all the cuticularised portions were clearly differentiated. The thickness of the cuticle was also measured. The seeds were then treated with strong sulphuric acid for short periods of time, well washed and soaked in water for twenty-four hours between each application. As soon as a seed was seen to swell hand sections were cut, stained and examined, and compared with those of the untreated seeds. In this way it was possible to determine the smallest amount that must be removed from the coat to enable water to enter the seed, and hence to determine the internal boundary of the impermeable covering.

In many cases the water appeared to enter at one point, and gradually pass to the remaining portion of the seed, causing it to swell also. This was, of course, most noticeable in the larger seeds, and in such cases the sections were cut from the part that swelled first.

The seeds selected for this special treatment were *Indigofera arrecta*, *Cytisus albus*, *Acacia melanoxylon*, *Melilotus alba*, *Albizzia lophantha* and *Canna indica*.

Indigofera arrecta.—The minute structure of the coat of this seed has already been described by Bergtheil and Day, who found a membrane to be present which stained with phosphoric acid and iodine, but not with chlor-zinc-iodine, and thence concluded that the membrane was not the same as ordinary cuticle. With carefully prepared chlor-zinc-iodine, however, I was able to obtain the ordinary staining results for cuticle in this case, thus confirming Dr. White's results.[2]

The average thickness of the cuticle was 0.008 mm. The walls of the palisade cells below the cuticle stained the purplish colour of hemicellulose rather than the blue characteristic of cellulose. In treating with sulphuric acid the periods were short ones of five, ten, fifteen and twenty minutes. There is a considerable variation in the resistance of the seeds to the action of the acid. Some swelled after fifteen minutes, while others required thirty minutes or longer to make them permeable. Sections of the swollen seeds showed that the cuticle had been removed by the action of the acid, and that the ends of the palisade cells were exposed on the surface. (Fig. 79 [3].) Sections for comparison were also made from a more resistant seed, which remained unswollen in water after previous treatment with the sulphuric acid for a corresponding period. In this the cuticle was still visible as a continuous layer, but was reduced to about one-third of its original thickness. (Fig. 79 [2].) From this it is evident that the resistant powers of this seed are due to the cuticle only, and that the inner layer is as impermeable as the outer, and that the whole layer must be removed in order to allow water to pass readily through the palisade cells and to enter the seed.

Cytisus albus.—The structure of the coat (Fig. 79 [4]) is practically the same as that of *Indigofera arrecta* except that the cuticle is only half the thickness of that of the latter seed, being 0.004 mm. in thickness. The seeds were treated with sulphuric acid for five, ten, fifteen and twenty minutes. There was some variation in the length of treatment required, but the average time was fifteen minutes, which was shorter than the average for seeds of *Indigofera arrecta.* This was only to be

1 Ann. Bot., vol. xxi., Jan., 1907.

2 Proc. Roy. Soc. Victoria, vol. xxi., pt. i.

expected, as the seed coats were so much alike in structure, and those with a thicker cuticle naturally required longer treatment. Sections of the swollen seeds showed that the cuticle alone had been removed by the acid, and that the palisade cells were intact, so that in this type also it is the cuticle alone which confers impermeability on the seed.

Acacia melanoxylon.—These seeds are also covered by a layer of cuticle which is much thicker than in either of the preceding types, being 0.013 mm. (Fig. 79 [5].) The walls of the palisade cells are of cellulose, and not hemicellulose, as was the case with the majority of seeds that I examined. As this cuticle was thicker than the others the periods of treatment were corresponding longer, and it was found, instead of swelling in water after about fifty minutes, as might have been expected, it was only after one hour and twenty minutes that they became permeable. Microscopic examination showed, as in the previous cases, that the cuticle only was gone, and that the palisade cells were unchanged, so it seems safe to conclude that the cuticle is of a more resistant nature than that of Cytisus albus or of Indigofera arrecta.

Melilotus alba.—The seed coat in this case is of an entirely different type. The outer layer consists, like the others, of palisade cells covered externally by a structureless membrane which, however, did not appear to be cuticle but hemicellulose. It stained majenta with chlor-zinc-iodine. To confirm this result I tested similar sections with phosphoric acid and iodine, and also with chlorophyll, but in no case did the outer membrane give the cuticle reaction.

With regard to the palisade cells themselves the greater part of the wall appeared to be composed of hemicellulose, and the outer ends only were cuticularised and microscopic examination showed the outer cuticularised ends projecting, as it were, into the external hemicellulose membrane. (See Fig. 1 [6].)

In seeds which had been soaked in sulphuric acid for twenty minutes the outer membrane, and, in addition, the cuticularised ends of the cells were dissolved away. Such seeds swelled readily in water. In order to find whether the outer membrane was in itself impermeable to water, some more seeds were treated for shorter periods in order to dissolve off the outside

covering without directly affecting the palisade cells. Such seeds swelled in water, and microscopic examination showed that the ends of the palisade cells were quite intact, but had separated from each other, as shown in Fig. 79 [7]. From this it would appear that the outer membrane is instrumental in conferring impermeability on the seed, though not directly responsible for it, as is the case with a true cuticle. It seems probable that it serves rather as a cement substance, by means of which the cuticularised ends of the cells are held closely together, thus forming a barrier through which the water cannot penetrate, and as soon as the membrane is removed, the ends separate, and the water passes in between them.

In all the foregoing cases the treatment also took place at average room temperature—i.e., 12 to 15 deg. C.

Albizzia (Acacia) lophantha.—The seeds used for this test were not fresh material as was the case with the other five, but old seeds which had remained buried in the soil for at least twenty-three years. They proved to be remarkably resistant to the action of sulphuric acid, and to have retained their full power of germination. I obtained also some fresh seed of the same kind, for purposes of comparison, and this was not only considerably less resistant, but had a much lower percentage of germination. This is explained by the fact that, during the time the seeds remained buried in the soil all the non-germinable and less resistant seeds had either decayed or germinated, and those that were left represented the naturally selected good seeds of many seasons. The degree of resistance varied to an astonishing degree; some of the seeds swelled after one to five hours in acid, about 38 per cent. required 40 hours' treatment to make them swell, while 6 per cent. only swelled after an application of over 80 hours. The average temperature during the treatment was 12 deg. C.[1] I made a second test, keeping the acid at 30 deg. C., and found that about 80 per cent. swelled after 7½ hours in acid, and the remainder at the end of 10½ hours. This was the only case in which I tried the effect of using sulphuric acid of different temperatures. Many seeds,

1 According to Hiltner (Arbeiten aus der Biolog. Abteil f. Land w. Forstwirtsch am Kaiserl. Gesundheitsamte Bd. III., p. 29, 1903. "Seeds of A. lophantha required 10-15 hours in H_2SO_4 to make them permeable—no temperature mentioned."

even after prolonged treatment with the acid, remained unswollen in spite of the fact that a considerable amount of the outer coat had obviously been removed. The reason for this can be seen by reference to the figures of *A. lophantha.* Fig. 80 a shows the structure of the untreated seed coat. It was covered externally by a distinct cuticle 0.015 mm. in thickness; there were two layers of palisade cells instead of one, as is more usual. The cells were of varying lengths, those of the deeper row formed an undulating surface, over which those of the outer were moulded in such a way as to form a level surface on the exterior of the seed. The walls of the outer palisade cells were entirely cuticularised, and those of the inner also for some distance from the outer end, the remainder of the wall was of ordinary cellulose, and the cell contents were protoplasmic. The cuticularisation ended abruptly, and in the stained sections its limit was marked by a sharp line running across the cells. The lumina of the cuticularised portions of the cells are coloured black in the figure as they were otherwise difficult to define, but as far as could be seen they were quite empty. Fig. 80 b is a section of a seed which had been treated with acid for several hours, and which remained unswollen in water, although a good portion of the testa had evidently been removed. It can be seen that the outer palisade cells were almost corroded away, but as the inner cells were still intact, it was impossible for water to enter the seed. Fig 80 c is a section of a seed which had swollen in water, and shows that as soon as the walls of inner cells were corroded away as far as the openings of the lumina, water could then run into the cell cavity, pass through the inner cellulose wall and so enter the seed.

Canna indica.—This was the only hard seed I examined that had not a definite cuticular membrane covering the surface. The coat consisted of palisade cells, the walls of which were cuticularised except at the inner ends. Running transversely near the middle of the cells was a definite line which did not appear to have any morphological existence, or even to mark the boundary between layers of varying cuticularisation, but which was apparently the result of an optical effect. The lumina were narrow, with two dilatations, a slight one at the outer end, and

a large one at the inner end; the latter had protoplasmic contents.

The shape of the lumina gives the cells a very characteristic appearance. At intervals across the lumina were delicate oblique partitions of cuticularised substance. The seeds swelled after about two hours in sulphuric acid at 22 deg. C. The coats of the swollen seeds were very soft, and it was difficult to cut satisfactory sections of them. So I embedded them in paraffin without dehydrating, and cut sections with a horizontal microtome. The sections showed that the palisade cells were corroded away somewhat irregularly, so that it was difficult to judge to what extent the corrosion was necessary in order to permit water to enter, but it seems probable that it must at least proceed just beyond the last cross partition in any one cell. The entry of water into the cell would cause such a distortion of the micellae of cellulose as to give rise internal stresses and strains would disturb the micellae in other parts, so that they would become forcibly separated, and this would enable the molecules of water to push their way in. The results of the above experiments are summarised in the following table:—

Seed.	Thickness of Cuticle.	Average time in sulphuric acid at 12-15°C. required to produce sw.	Impermeable portion of Seed.
Indigofera arrecta -	0.008 mm.	15–30 min. -	Cuticle
Cytisus albus - -	0.004 mm.	15 min. - -	Cuticle
Acacia melanoxylon	0.013 mm.	1 hr. 20 min. -	Cuticle
Melilotus alba -	No true cuticle	10 min. - -	Cuticularised ends of palisade cells
Albizzia lophantha -	0.015 mm.	40 hrs. at 12° C. 7 hrs. at 30° C.	Cuticle and palisade cells
Canna indica - -	No cuticle	2hrs. - -	Palisade cells only

Nature of Cuticle and Methods of Softening Hard Seeds.

In the formation of cuticle the cell walls have become impregnated with cutin. Whether these materials penetrate the cell wall as a waxy substance, or whether they are deposited as the result of subsequent chemical change, is unknown. Van Wisselingh,[1] contrary to the opinions of Von Hohnel and Zim-

1 Archives Néerlandaises des Sciences Exactes et Naturelles, tome xxviii., 1894.

merman, concluded that cutin must always pass through cellulose to reach cuticle. In this it differs from cork in which the suberin is formed in direct contact with the protoplasm. The most important impregnating substances are compounds of glycerine with stearic, palmitic and suberic acids, and these, being of a fatty nature, should be soluble in ordinary fat solvents, saponified by potash, and should have a definite melting point. Associated with these fatty substances are other non-melting materials, and so intimate is the connection between the two that it is often difficult for the various reagents to act on one of the two impregnating substances, as its action may be hindered by the presence of the other. For example, a temperature of over 200 deg. C. may be required to cause physical decomposition of cutin, but once the materials are separated they will remain liquid at a much lower temperature. Possibly the cutin substances exist in the intact cuticle in a kind of loose chemical combination.

The work hitherto has been done with leaves of Oleander, Eucalyptus, Holly, etc., in which the cuticle, though well developed, cannot compare for thickness with that present on the outside of many hard seeds. Van Wisselingh in his work distinguishes between cuticle and thickened cuticularised cell walls. In the former he found only a trace of cellulose or none at all, while the cuticularised walls had a definite framework of cellulose. The cuticle in these leaves would seem therefore to be an exudation from the cells of the epidermis or a deposition of cuticular substances on the outside of the cell walls of such cells. It seems, however, highly improbable that a cuticle of the thickness found covering hard seeds should exist without a framework of some kind, but much more likely that it should be formed by the deposition of cutin within the substance of the original cell wall (or some modification of it), which, in consequence, would increase greatly in thickness. The particles of cutin would be evenly distributed among the micellae of the cellulose forming the framework.

If such seeds were treated with fat solvents the waxy materials should be dissolved out, and the insoluble basis be left, and it would be possible to detect the presence and nature of the latter by using suitable stains. If an outer membrane can be

shown still covering the seed, and the thickness of it be the same as that of the original cuticle, it would be safe to conclude that in the coverings of hard seeds at least an insoluble basis is present throughout.

The method used was as follows—the seeds were treated for varying lengths of time with chloroform, warm alcohol, turpentine, and strong caustic potash, sections were made of the seeds which swelled in water after the treatment, these were stained as before with chor-zinc-iodine and compared with similar preparations of untreated seeds. The seeds used were the same as those selected for the examination of the structure of the seed coat. Of the reagents used chloroform and caustic potash gave most satisfactory results, and turpentine had no effect whatever. Boiling absolute alcohol produced swelling in all cases, but as soaking in water or 70 per cent. methylated spirit at a corresponding temperature gave similar results it seems probable that the action is mainly a physical one, due to the melting of the fatty substances by the action of heat.

Indigofera arrecta and *Cytisus albus* gave similar results in all cases. Boiling in absolute alcohol for two hours produced swelling, and sections of the swollen seeds showed that the cuticle had entirely disappeared. One hour in boiling alcohol caused a few seeds to swell, and in these also the cuticle was gone, but there was a distinct rather ragged bluish line along the outer margins of the cells. As the sections dried this line seemed to shrink somewhat, although, as it was not very thick in the first place, the change was not remarkable. Maceration in chloroform at 30 deg. C. for eighteen weeks was also instrumental in producing swelling, and the stained sections of these seeds showed a marked contrast with those of untreated seeds. The outer membrane no longer appeared dark brown, but was tinged with the violet colour of hemicellulose. (See Plate 81, a, b.) A similar result was obtained by soaking the seeds in a saturated solution of caustic potash at 30 deg. C. for four weeks, or by boiling in the same for 5 min. The sections after this last method were unsatisfactory on account of the excessive softening of all the parts by the action of the potash, whereas prolonged soaking in chloroform appears to remove the cutin without affecting in the least the structure of the carbohydrate basis in which it is embedded.

Seeds of Acacia melanoxylon gave similar results as far as swelling was concerned. Three hours' treatment in boiling alcohol and in water at the same temperature caused a number of the seeds to swell on subsequently soaking in water, and the power of swelling was also restored by maceration for 18 weeks in chloroform at 30 deg. C. When, however, a comparison was made between stained sections of treated and untreated seeds, no difference could be detected between them, and both appeared as shown in Plate 81, c. The most probable explanations seemed that either there was some other material present in the outer wall which prevented the cellulose reaction or that the supporting tissue was some substance other than cellulose. If the former were the case the most likely material to mask the cellulose colour would be tannin. The seeds were therefore tested for this substance, with potassium cyanide, ammoniacal solution of ammonium picrate, lead acetate and caustic potash followed by sulphurous acid, and with ferric chloride,[1] and in each case the result was negative. The material which would be most likely to occur in the place of cellulose is pectose. According to Van Wisselingh pectose is somewhat like cellulose, but more gelatinous in character. In case the framework should be a mixture of pectose and cellulose, the sections were macerated in cuprammonia until the walls of the palisade cells, which were pure cellulose, were dissolved away; they were then stained with iodine and phosphoric acid, which stains pectose pale yellow, but as this colour did not differ much from that shown by the untreated seeds a further test was necessary. Following the directions of Van Wisselingh[2] for the removal of pectose the seeds were boiled repeatedly in dilute acids and alkalis, and washed between each operation, but this treatment softened the seeds to such an extent that section cutting was impossible. The second method of heating in glycerine from 250-300 deg. C. proved more satisfactory, and after half-an-hour's treatment the outer membrane was quite dissolved away (Plate III. d), so it seemed that in this case the framework of the cuticle was pectose and not cellulose or hemicellulose. This variation in the nature of the supporting

1 Methods given in Czapek Biochemie.

2 Czapek Biochemie, i., p. 552.

tissue is of interest because correlated with it, as already shown, is a greater resistance to the action of sulphuric acid.

The results obtained with Melilotus alba did not correspond with any of the others on account of the different nature of its seed coat. Boiling in absolute alcohol for five minutes or for three-quarters of an hour in 70 per cent. methylated spirits at 73 deg. C. produced swelling, but there was no apparent change in the structure of the seed coat. The swelling must have been due to the disturbance of the micellae of hemicellulose by the action of heat causing the cuticularised cells to become separated, and not to any actual change in the cuticularised substance. Hemicellulose, being unaffected by chloroform, effectually prevented the latter from reaching and dissolving out the fats in the cuticularised walls, and maceration in chloroform at 30 deg. C. for eighteen weeks had no effect whatever on the seeds. Sections were then made and kept in chloroform at the same temperature for a period of four weeks, and at the end of that time were washed and stained with chor-zinc-iodine. The whole cell wall now showed the hemicellulose colour, which was darker at the tip, where it had been previously cuticularised. (Plate 81 c.) The action of caustic potash was to entirely remove the outer membrane and to take out, probably by saponification, the waxy substances from the cuticularised parts.

In the case of *Albizzia lophantha* some of the tests were made with both old and new seed, and although the final results were the same, the degree of resistance of the two samples differed widely. For example, two hours in boiling alcohol caused 69 per cent. of the fresh seeds to swell, whereas three hours were required to produce a similar result with the old seed. As in all other cases the alcohol had no apparent effect on the structure of the cuticularised parts. In using caustic potash, four weeks at 30 deg. C. or one hour on a boiling water bath were required to produce swelling. The seeds' coats were softened to such a degree that section cutting was out of the question, but parts mounted and stained with chlor-zinc-iodine gave a distinct hemicellulose reaction. Maceration in chloroform for 18 weeks at 30 deg. C. also produced swelling, and in prepared sections the palisade cells which had previously stained

brown showed the purplish colour of hemicellulose (Pl. 81 f, g).

Canna indica served to confirm the above results. After 9 weeks in chloroform one out of ten swelled, and the seed coat gave the cellulose reaction, and a section of such a coat stained with chlor-zinc-iodine is figured in Pl. 81 h.

Swelling was also produced by the action of caustic potash, but seeds required long maceration in this substance to produce satisfactory results—1 hour in test tube on boiling water bath, and over 3 months at 30 deg. C.

Summary.

1. The general result of the series of germination tests in the first part of this paper confirms Prof. Ewart's statement that the macrobiotic seeds belong for the most part to the order Leguminosae, that the highest percentage of germination occurs among cuticularised seeds, and that the more impermeable the cuticle the higher is the percentage of germination. This fact is demonstrated by the results obtained with *Acacia acinacea*, *A. decurrens* and *A. pycnantha*, from these samples those seeds which swelled in water showed a feeble power of germination, while hard seeds from the same sample, which required prolonged treatment with sulphuric acid to make them swell, showed a percentage of germination from fifty to one hundred. There were a few exceptions to the above, which are worthy of note. *Eucalyptus calophylla* and *E. diversicolor* both possess macrobiotic seeds although unprovided with any specially impermeable coverings; they are further remarkable, as longevity is not as a rule a characteristic of large seeds containing oil. Another interesting result was obtained in the case of *Sorghum*, in which one sample sixteen years old showed fifteen per cent. of germination. This places *Sorghum* above *Triticum*, which is one of the longest lived of the cereals.

2. The impermeability of hard seeds in all those examined is due to the presence of cutin, which may—(a) form a membrane on the outside of the seed as in *Cyticus albus*, *Indigofera arrecta*, and *Acacia melanoxylon*, (b) be laid down in the cell walls of the palisade cells as in *Melilotus alba* and *Canna indica*, or (c) be found both as an outer membrane and in the walls

of the palisade cells as well, as in *Albizzia lophantha.* The degree of impermeability does not depend only on the thickness of the cuticle, but probably on the proportion of waxy substance present in the membrane.

3. The cuticle found covering hard seeds differs somewhat from that existing on many leaves. In the former it is an exudation beyond the cell wall, whereas in the latter it consists of a definite basis throughout which the particles of cutin are deposited. In a thick cuticle like that of *Albizzia lophantha* the greater thickness is probably due, in part at least, to a greater proportion of cutin being present, so that the degree of separation of the micellar basis must be greater than in a thinner cuticle like that of *Cytisus albus* or *Indigofera arrecta.* The nature of the substance forming the basis may vary somewhat. Judging from the seeds examined it seems, in the majority of cases, to be hemicellulose; in *Canna indica* it seemed intermediate between cellulose and hemicellulose, and in one case (*Acacia melanoxylon*) it was made up of pectose, and in this last case the cuticle was, curiously enough, of a more resistant nature than that of those which had a basis of hemicellulose.

EXPLANATION OF PLATES. LXXIX.—LXXXI.

Plate LXXIX.

Fig. 1.—Seed coat of Indigofera arrecta.
Fig. 2.—Same after short treatment with sulphuric acid.
Fig. 3.—Same after longer treatment with sulphuric acid.
Fig. 4.—Seed coat of Cytisus albus.
Fig. 5.—Seed coat of Acacia melanoxylon.
Fig. 6.—Seed coat of Melilotus alba.
Fig. 7.—Same after treatment with sulphuric acid.

Plate LXXX.

Fig. a.—Seed coat of Albizzia lophantha.
Fig. b.—Same unswollen after treatment with sulphuric acid.
Fig. c.—Same swollen after prolonged treatment with H_2, SO_4.
Fig. d.—Seed coat of Canna indica.

Plate LXXXI.

All sections stained with chlor-zinc-iodine.

Fig. a.—Seed coat of Indigofera arrecta after maceration in chloroform.

Fig. b.—Similar sections of Cytisus albus.

Fig. c.—Seed coat of Acacia melanoxylon apparently unchanged by maceration in chloroform.

Fig. d.—Same after treatment with glycerine at 200 deg.

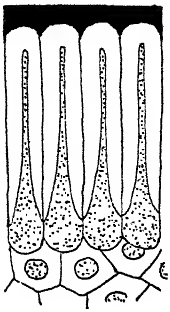
Fig. e.—Seed coat of Melilotus alba after section treated with chloroform.

Fig. f.—Seed coat of Albizzia lophantha (untreated).

Fig. g.—Same after maceration in chloroform.

Fig. h.—Seed coat of Canna indica after maceration in chloroform.

The coloured plate accompanying this paper was originally printed in the "Journal of Agriculture," and I have to thank the Hon. G. Graham, M.L.A., Minister of Agriculture, for the gift of copies of the plate for inclusion in the present volume.



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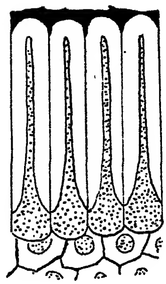

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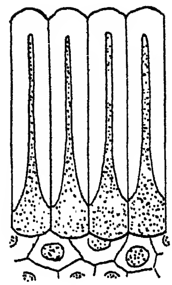

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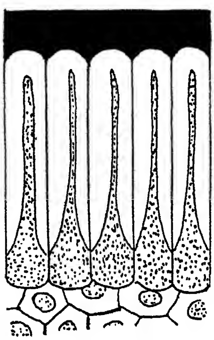

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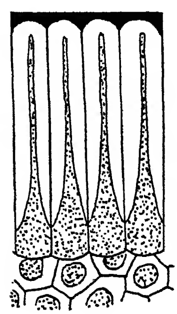

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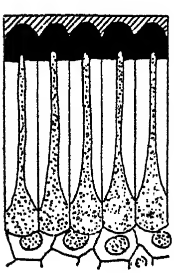

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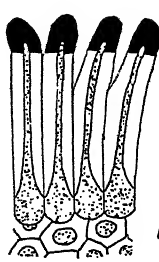

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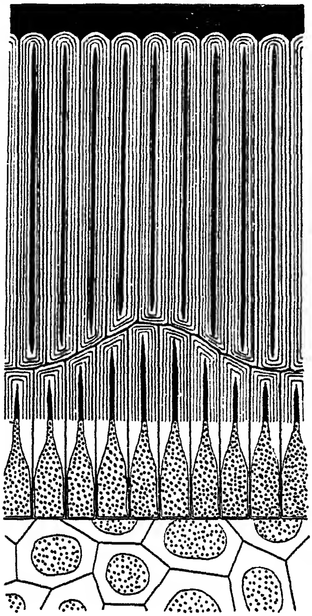

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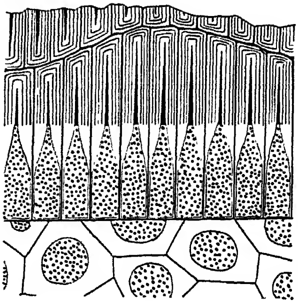

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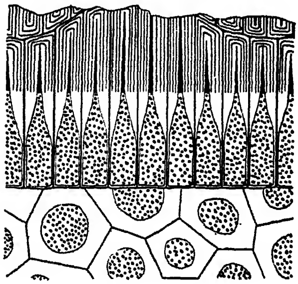

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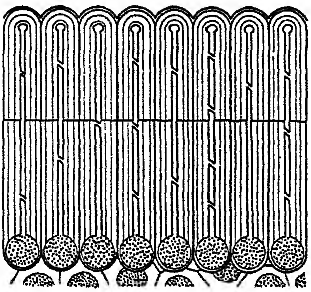

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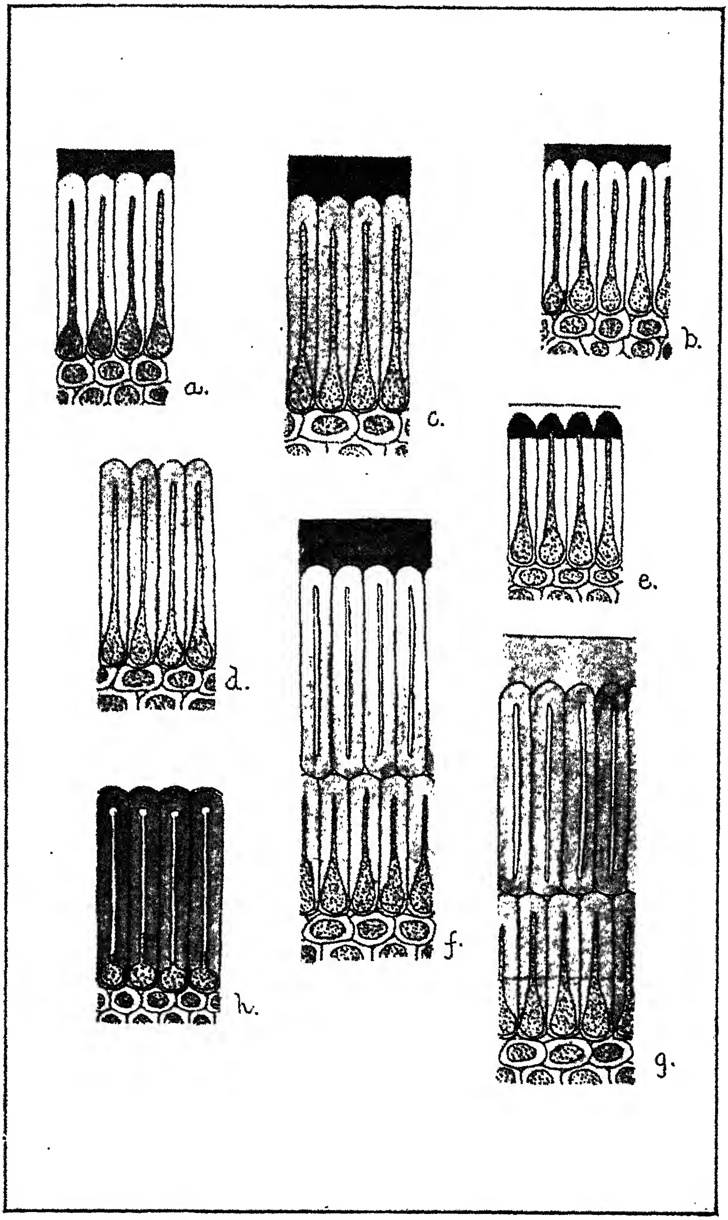


Bertha Rees, Del

SECTIONS OF SEED COATS OF HARD SEEDS.

[PROC. ROY. SOC. VICTORIA, 23 (N.S.), PT. II., 1911].

ART. XXXII.—*On some supposed Pyritized Sponges from Queensland.*

BY FREDERICK CHAPMAN, A.L.S.,

Palaeontologist to the National Museum, Melbourne.

(With Plate LXXXII.).

[Read 8th December, 1910].

Introduction.

The two specimens forming the subject of this note were purchased a few years ago for the National Museum collection from a Melbourne dealer, by whom they were regarded, not unnaturally, as "fossil fruits." It is fairly conclusive, however, from their shape and superficial characters, that they are pseudomorphs of typical Upper Cretaceous siliceous sponges. These pyritized fossils bore the rather vague locality label "Darling Downs, Q." They are, therefore, presumably from the Desert Sandstone formation (Upper Cretaceous), which is so extensively exposed in certain parts of Queensland. Another fossil specimen of very great interest accompanied the sponges in the same collection, which helps to corroborate the location of these fossils. It is a nearly perfect specimen of an internal cast of *Micraster*, which in all probability can be referred to the *M. sweeti* of Mr. Etheridge, junr., and which up to the present was represented only by an imperfect cast from the Desert Sandstone of Maryborough, Queensland.[1]

The sole exposure of Desert Sandstone on the Darling Downs is in the Derby District, where an elongated outlier, averaging about ten miles across, extends in a south-easterly direction from Wambo, south of the Condamine River, to Mount Domville. Hence it is suggested that this is most likely the locality which yielded these fossil pseudomorphs.

1 Geol. and Pal. of Queensland and New Guinea, 1892, pp. 559, 560.

The pyritized (?) sponges now described resemble the Lithistid types of the characteristic Upper Cretaceous genus, *Siphonia.* The material which has replaced these sponges is now in the mineral form of marcasite. A radial structure in the interior is visible through the cracks which have developed in one of the specimens. On account of the complete crystalline replacement of the mass of the sponge, no spicular structure is preserved. As before stated, we have only the evidence of shape and superficial characters on which to base conclusions. No sponge remains appear to have been recorded from Australian Upper Cretaceous rocks; and the Lower Cretaceous has afforded only one genus, in the Hexactinellida, viz., *Purisiphonia.*

Description of the Specimens.

cf. Genus Siphonia (Parkinson), Goldfuss pars.

Specimen A. (Plate LXXXII., Figs. 1 *a*, *b*.)

This specimen is apple-shaped, or, perhaps, more accurately, melon-shaped. It is subspherical, but more elongated on the vertical axis; very tumid in the zone of the basal third; depressed and slightly tapering above the middle, where the surface is tumulose. Upper surface rounded, with a relatively small cloaca. Stalk inserted in a slightly depressed area. Lateral surface of the body with irregular, anastomosing or branching longitudinal grooves, giving the sponge the characteristic rugose appearance often present in *Siphonia.* (?) Vestiges of the fine incurrent openings may be seen on the surface of the cast, and more thickly disposed in the depressed parts.

Measurements.—Greatest length of body, 47.25 mm.

Greatest width of body, 45 mm.

Diameter of cloacal opening, circ. 4.5 mm.

Length of peduncle, 4.75 mm.

Width of peduncle at base, 8.75 mm.

Remarks on specimen A.—The form of this pseudomorph may be compared with that of the typical Cenomanian species, *Siphonia tulipa,* Zittel, which is so common in the Upper Greensand of Warminster and Blackdown, England. A critical comparison shows the Queensland fossil to be nearest the

example of the above species figured by G. Sowerby,[1] under the name of *Siphonia pyriformis* (non Goldfuss); and re-figured by Zittel.[2]

Specimen B. (Plate LXXXII., Figs. 2 *a*, *b*.)

In form this fossil is subcylindrical, slightly recurved, that is to say, concave and convex on opposite lateral faces respectively; bluntly rounded at the apex, with a conspicuous cloacal aperture, now filled with a projecting plug of pyrites, from which radiate a few irregular and obscure (?) excurrent canals. Distal end furnished with a short stout stalk, which, at the junction with the sponge body, is seated in a slight depression. Surface of sponge relieved with lobular swellings. In places the surface shows patches of especially vermicose character, which may be the vestiges of former areas of the incurrent system of canals. This structure is now, however, obscured by the development of crystal facets over the surface of those areas.

Measurements.—Greatest length of body, 45 mm.

Greatest diameter of body, 32 mm.

Diameter of cloacal opening, 5.75 mm.

Length of peduncle, 11 mm.

Width of peduncle, 7.25 mm.

Remarks on specimen B.—This example at first sight appeared to belong to the genus *Phymatella*, Zittel, on account of its subcylindrical form. The rounded summit and shape of the cloacal area, however, and the impressed peduncular seat exclude it from that genus. On the other hand, certain subcylindrical varieties of *Siphonia tulipa*, Zittel, show that our specimen is related to that specific type. Thus, a closely comparable form is that figured by Sollas,[3] under the name of *S. pyriformis*, Sow., var. *cylindrica*, Courtillier. We here follow Dr. G. J. Hinde[4] in placing Sowerby's species *pyriformis*, and also Prof. Sollas' so-referred species shown in his Figures 1, 3, 4, 6, 8 (*loc. cit.*) with Zittel's *S. tulipa*. We may therefore regard this Queensland fossil as probably referable to *S. tulipa*,

1 Geol. Trans., Series 2, vol. iv., 1836, p. 340, pl. xva., figs. 4 and 5.
2 Traité de Paléontologie (French ed.), 1883, vol. i., Paléozoologie, p. 169, fig. 80*b*.
3 Quart. Jour. Geol. Soc., vol. xxxiii., 1877, pl. xxv., fig. 4.
4 Cat. Foss. Sponges, Brit. Mus. (Nat. Hist.), 1883, p. 64.

Z. var. *cylindrica*, Court. The last-named author recorded his variety from the Cenomanian (Lower Chalk) of Saumur, Maine-et-Loire, France.[3]

It is worth noting, as further stratigraphical evidence of the homotaxy of the Desert Sandstone with the Upper Cretaceous elsewhere, that both *Siphonia tulipa* and its variety *cylindrica* occur in Europe in the latter series.

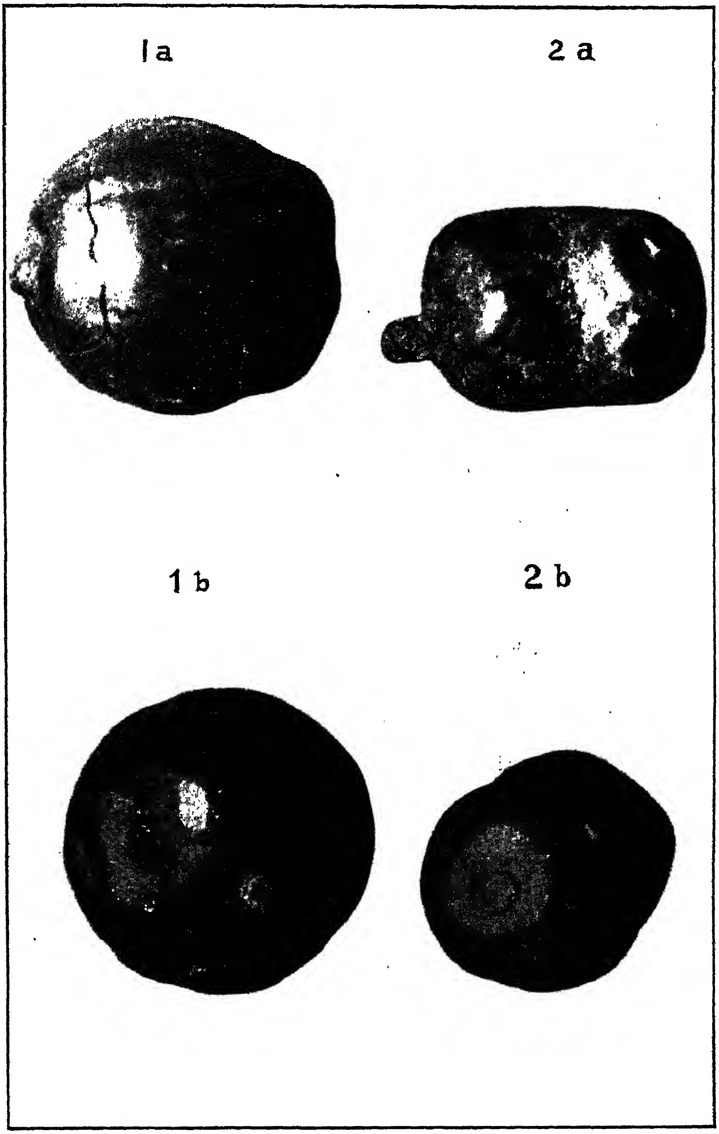
Explanation of Plate LXXXII.

Fig. 1.—Pyritized sponge, cf. *Siphonia tulipa*, Zittel. *a*, Lateral aspect; *b*, apical aspect.

Fig. 2.—Ditto, cf. *S. tulipa*, Zittel, var. *cylindrica*, Courtillier. *a*, lateral aspect; *b*, apical aspect.

Figures slightly less than natural size..

1 Courtillier, A. "Eponges fossiles des sables du terrain Crétacé supérieur des environs de Saumur, étage Sénonien de D'Orbigny" (Extrait des Annales de la Société Linnéene de Maine-et-Loire), 1861.



F.C. Photo.

Pyritized Sponges: Upper Cretaceous, Queensland.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. II., 1911].

Art. XXXIII.—*A Revision of the Species of Limopsis in the Tertiary Beds of Southern Australia.*

By FREDERICK CHAPMAN, A.L.S., &c.

Palaeontologist to the National Museum. Melbourne.

(With Plates LXXXIII.-LXXXV.).

[Read 8th December, 1910].

Introduction.

In the course of preparing a Catalogue of Type Fossils in the National Museum, some difficulties arose with regard to the names of our fossil species of the genus *Limopsis*. The separation of species in this genus is somewhat intricate on account of the closely graduated characters of some of the forms, although they can generally be grouped around certain central types. Furthermore, the genus seems to have been remarkably susceptible to any slight differences in the local surroundings, and to the nature of the sediments which were laid down in the various habitats. The evidence gathered from a consecutive study of the range and variation of species of this genus throughout the Victorian Tertiaries tends to show that the Tertiary sedimentation in this part of the world was rapid and continuous from the base to the summit, In other words, the species to which our fossil examples pertain are, generally speaking, persistent almost throughout the series; and in two important cases there are no palaeontological gaps occurring which allow the appearance from foreign sources of any forms distinct in shape or ornament, our species being traced from point to point in all their gradations.

Undoubtedly the central type-form of the genus is closely allied to that which Sir F. McCoy identified with the commonest

of our Tertiary examples of *Limopsis*, viz., *L. aurita*, Brocchi sp. It will be seen, however, in the detailed description, that the Patagonian and New Zealand species, *L. insolita*, Sow. sp., is closer to the Australian form, and, indeed, specifically identical.

In the present revision the relationships of the living Victorian and kindred species of the genus have been discussed; and it may here be suggested that the trouble of making a further and general comparison of the living with the fossil fauna of the Australian marine areas would be amply repaid by the acquisition of a correct knowledge of the percentage relations one to the other.

The specific names it is proposed to adopt in this paper are the following:—

Name.	Salient Characters.
L. morningtonensis, Pritchard	Valves depressed, subquadrate; concentric ribs accentuated. Ornament in later stage sectinate.
L. maccoyi, sp. nov. (= *L. belcheri*, McCoy, non Adams and Reeve)	Valves depressed, long-ovate, oblique; radial ribs accentuated. Ornament fimbriate.
L. multiradiata, Tate	Valves nearly as above, not so oblique radial ribs bifurcating. Ornament margaritate.
L. beaumariensis, sp. nov. (= ? *L. forskali*, Adams, *fide* Tate)	Valves subtrigonal, ventral border long, moderately deep to shallow Ornament nearly as in *L. maccoyi*, but cancellate.
L. insolita, G. Sowerby, sp.	Valves deep, subovate, oblique, occasionally subtrigonal; with well-marked concentric laminae, crossed by fine, pseudo-divergent striae. Ornament malleate.

Description of Species.

Limopsis morningtonensis, Pritchard.

(Plate LXXXIII., Fig. 1; Pl. LXXXV., Fig. 7).

L. morningtonensis, Pritchard, 1901, Proc. R. Soc. Vict. vol. XIV., N.S., pt. I., p. 24, pl. II., Figs. 6, 6*a*.

Abridged Description (for full details see above).—Shell roundly quadrate, depressed; slightly oblique, with a small but

prominent acute and incurved umbo. Hinge-line nearly straight. Ligament pit triangular, well marked. Teeth, 5-9 anterior; 4-7 posterior, unequal, median strongest. Internal margin of shell broad, flat; interior finely radiately striate. Exterior with strong concentric ridges, crossed by very faint striae. Type, height, 14 mm.; length, 12.5 mm.

Distribution.[1]—Balcombian.—Balcombe's Bay; Grice's Creek; Altona Bay Coal Shaft; Muddy Creek (Lower Beds) near Hamilton; Gellibrand River; Orphanage Hill, Geelong; Skinner's, Mitchell River, Gippsland.

Janjukian.—Batesford; near Griffin's Farm, Moorabool River; below Curdie's Steps; Fishing point, R. Aire.

Observations.—This species is a comparatively rare form, and is not easily mistaken for any of the other species, except it be the young forms of *L. maccoyi.* The distinguishing characters of the latter are the strong radial riblets, the fimbriate ornament and the greater obliquity of the shell.

Limopsis maccoyi, sp. nov.

(Pl. LXXXIII., Fig 2; Pl. LXXXV., Fig. 8).

L. belcheri, McCoy (non Adams and Reeve), 1875, Prod. Pal. Vict., Dec. II., p. 25, pl. XIX., Figs. 8, 9.

Relationships.—Not a little confusion formerly existed regarding the identification of the recent species of *Limopsis* ascribed by McCoy to *L. belcheri.* This has now been satisfactorily settled, so far as the living Australian examples are concerned, by Mr. Chas. Hedley.[2] The name of the living form now stands as *L. tenisoni*, T. Woods (syn. *L. bassi*, E. A. Smith). The species *L. belcheri*, Adams and Reeve, is a distinct, although related form, from the Cape of Good Hope.

The fossil species common in our Balcombian strata, and occasionally found in the Janjukian and Kalimnan, bears a general resemblance both to *L. belcheri* and *L. tenisoni.* It is

1 The sequence of the Balcombian and Janjukian Series here followed is the same as that adopted by Messrs. Tate and Dennant, viz., the Balcombian as the older. The present view is strongly suported by palaeontological evidence from the Mallee borings now under description, and also by a close study of the microzoa of the Tertiaries of Victoria and elsewhere.

2 Mem. Australian Mus., No. iv., 1902, p. 297.

specifically distinct from the recent *L. tenisoni* in the following particulars:—

	Outline.	Ornament.	Dental Armature
L. maccoyi -	Long ovate, very oblique in gerontic stage.	Radial stronger than concentric, the latter being wavy and fimbriate.	Teeth short, curved, comparatively few.
L. tenisoni -	Roundly ovate, oblique in gerontic stage.	Radial ornament strong, some undulose; interspaces occupied by fine, closely set bars, not so wavy as in *L. maccoyi*.	Teeth longer, more numerous.

Ligament pit in the fossil species usually smaller.

The description of this form by McCoy, under the name of *L. belcheri* (loc. supra cit.) is so full and precise as to obviate any further reference to its specific characters here. It may, however, be remarked in passing, that specimens in the neanic stage usually show a crenulated inner margin, as in the northern form, *L. aurita;* but this character is lost in the later development of the shell.

This fossil form appears to be the progenitor of the living species, as shown by its shape, and also by the general type of ornament, which in *L. tenisoni* is less redundant, the fimbriation being reduced to beads on the riblets, and to curved bars in the interspaces.

The differences between the Balcombian forms[1] and the living are so marked as to warrant a new name, and hence the shell termed *L. belcheri* by McCoy, and later confused by various authorities with some other tertiary shells of the same genus, is here re-named *L. maccoyi* in honour of its first describer.

Both *L. morningtonensis*, as before stated, and *L. multiradiata*, are somewhat related in outline, the latter being principally distinguished by its interrupted and bifurcated ribs.

Distribution.—Balcombian.—Balcombe's Bay and Grice's Creek, Port Phillip; Gellibrand River, three miles W. of mouth (G.S.V.).

Janjukian.—Bird Rock Cliffs near Torquay (G.S.V.), very rare.

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1 The Kalimnan forms are smaller and are probably annectant with the recent species This is borne out by the intermediate character of the surface ornament.

Kalimnan.—Beaumaris (G.S.V.), rare; the majority of the shells referred to as *L. belcheri* from Moorabbin (= Beaumaris) by McCoy (loc. supra cit., p. 26), are herein described as a new species, *L. beaumariensis;* it was formerly doubtfully identified with the Japanese shell, *L. forskali*, Adams, to which it bears some affinity. Also "Forsyth's," Grange Burn, near Hamilton, and "McDonald's," Muddy Creek (F. C. coll.).

LIMOPSIS MULTIRADIATA, Tate.

(Pl. LXXXIV., Fig. 4; Pl. LXXXV., Fig. 10).

L. multiradiata, Tate, 1886, Trans. R. Soc. S. Austr., Vol. VIII., p. 135, pl. XII., Figs. 1a, b. G. F. Harris, 1897, Cat. Tert. Moll. in Brit. Mus., pt. I., Austr. Tert. Moll., p. 346.

This species is allied to *L. maccoyi;* but is distinguished by its bifurcating riblets and the wavy, tessellated ornament. It is also rounder in outline than either *L. maccoyi* or *L. insolita.*

Distribution.—Localities all in South Australia. Adelaide Bore; Aldinga; Ninety Mile Desert.

LIMOPSIS BEAUMARIENSIS, sp. nov.

(Pl. LXXXIV., Fig. 6; Pl. LXXXV., Fig. 12).

L. forskali, A. Adams (*fide* Tate), 1898, Trans. R. Soc. S. Aust., Vol. XXII., p. 68, list name.

Description.—Shell subtrigonal, never very oblique, usually thick, comparatively tumid. Nearly equilateral up to the neanic stage, becoming slightly oblique in the ephebic and gerontic phases. Ligament pit large and triangular. Hinge-line strongly arched. Type specimen with 9 anterior and 9 posterior teeth; another specimen with 7 anterior and 8 posterior teeth. Ornament consisting of well marked, slightly undulating primary riblets, with from 0-4 secondary riblets in the interspaces, crossed by fainter, equidistant growth-lines, producing a distinct cancellated surface. Interior of valve finely striate; internal margin flat, smooth. A fairly constant variety is often

met with at "McDonald's," Muddy Creek, and other Kalimnan localities, distinguished by its thin, depressed form, apiculate umbo and stronger concentric striae. This might be appropriately termed var. *depressa*, nov.

Dimensions.—Type: Height, 20.25 mm.; length, 21 mm.; depth of valve, 6 mm.; length of hinge-line, 9.25 mm.; height of ligament pit, 1.75 mm. Smallest sample: Height, 11 mm.; length, 11.5 mm. Locality of type, Beaumaris, from a bed of white clay (Kalimnan), G.S.V. coll.

Relationships.—Amongst a dozen examples of the genus *Limopsis* from Beaumaris labelled as *L. belcheri* by McCoy, in the National Museum collection, two are undoubtedly referable to *L. maccoyi*, whilst the remainder, which are deeper shells of a subtrigonal form and of a stout build, belong to the species now described as *L. beaumariensis*. The dental armature is strong, although the number of teeth is the same as in *L. maccoyi*, from 15-19. Compared with *L. insolita*, that species rarely has more than 14. The ligament pit is long and deep as in *L. insolita*, but the ornament is clearly that of *L. maccoyi*. This form is extremely interesting as pointing to a local hybridisation of two tolerably distinct shells.

Observations.—Professor Tate, in objecting to McCoy's identification of the recent Australian *Limopsis* with the Cape of Good Hope species, *L. belcheri*, suggested its alliance to *L. forskali*, Adams.[1] In subsequent lists Prof. Tate records *L. forskali* as occurring in the Tintinarra Bore, S. Australia, in pre-Kalimnan strata.[2] This identification of the Kalimnan fossil was perpetuated by later authors, presumably by comparison with Tate's examples. In the Dennant collection in the National Museum some very fine shells of the above species from the younger Muddy Creek beds (Kalimnan) are labelled "*L. forskali*"; whilst shells of the form now referred to as *L. maccoyi*, from the older Muddy Creek beds (Balcombian), were labelled by the late Mr. Dennant as "*L. forskali*, var." There is no doubt, therefore, as to the shell ascribed by Tate to *L. forskali*, since Mr. Dennant had carefully compared his specimens with Tate's named examples.

1 Trans. Roy. Soc. S. Aust., vol. xxi., 1897, p. 48.
2 Ibid., vol. xxii., 1898, p. 68.

With regard to *L. forskali,* this shell was described by Adams from recent examples (dead shells), from the shores of Japan.[1] No figure of the species was given, and, although the description agrees in many particulars with the present form, the Japanese shell differs in having the radial riblets alternately large and small, whereas the radii in the fossil species shows every gradation between simple primary riblets and intermediate riblets from 1 to 4 in number. In the absence of authentic specimens of *L. forskali,* and bearing in mind the difference in ornament noticed above, it appears safer to designate our common Kalimnan species by a distinctive name.

The examples of L. beaumariensis from the Kalimnan series of Grange Burn and McDonald's, near Hamilton, are generally much abraded and ironstained, and in some cases the shell surface is so highly polished as to show that they have been undoubtedly subjected to wind erosion.

Distribution.—The distribution of the above species does not coincide with that of *L. forskali* as recorded by Dennant and Kitson[2] in their Barwonian group of localities, since the former author had compared *L. belcheri* (=*L. maccoyi,* sp. nov.) with that form (*teste* Dennant Coll.).

Barwonian.—Lake Bullenmerri, Camperdown. G.S.V. coll.

Kalimnan.—Beaumaris; McDonald's, Muddy Creek; Forsyth's, Grange Burn; Jemmy's Point, Gippsland (in Dennant coll. as "? *Limopsis insolita,* var.").

LIMOPSIS INSOLITA, G. Sowerby sp.

(Pl. LXXXIV., Fig. 5; Pl. LXXXV., Fig. 11).

Trigonocoelia insolita, G. Sowerby, 1846, in Darwin, Geol. Obs. S. America, p. 252 (2nd ed. 1876, p. 608), Pl. II., Figs. 20, 21.

Limopsis insolita, Sow. sp., Zittel, 1864, Reise der "Novara," Vol. I., Abth. II., p. 48, Pl. XIII., Fig. 1.

L. aurita, McCoy (non Brocchi sp.), 1875, Prod. Pal. Vict., Dec. II., p. 23, Pl. XIX., Figs. 5-7.

L. insolita, Sow. sp., Harris, 1897, Cat. Tert. Moll. Brit. Mus., Pt. I., Australasia, p. 344.

1 Proc. Zool. Soc. Lond., 1862, p. 230.

2 Rec. Geol. Surv. Vict., vol. i., pt. 2, 1903, p. 122.

Relationship to L. aurita.—The Victorian species generally referred to under the name of *L. aurita*, Brocchi sp., is closely related to that well-known European type of shell; but it differs in the following particulars from Brocchi's original figure and description.[1] The shell is heavier when in the ephebic and gerontic stages; is more ovate, as well as more oblique, rarely being subtrigonal,[2] as in Brocchi's figure of the Pliocene form; and is peculiarly striate in an apparently double divergent series on each concentric lamina. The original descriptions of Brocchi and G. Sowerby are here given.

"*Arca aurita*," Brocchi.

Shell ovate, oblique, narrow above; concentrically ridged, rugae crowded, elevated. Hinge-line ear-shaped, with a distinct triangular pit. Margin entire.

"*Trigonocoelia insolita*," G. Sowerby.

Shell subovate, thickened, very oblique, smooth; ligament pit trigonal, laterally elevated; teeth few, large.

In neither of these original descriptions is there any mention of radial striae or ribs. With regard to *L. aurita*, judging from a fine series of specimens in the National Museum collection, it is clear that there has been either great latitude in the identification of specimens ranging from the Middle Oligocene to Pliocene, or on the other hand, several species have been confused under the one name. For instance, specimens of *L. aurita* (ex. Krantz coll.) from the Middle Oligocene of Flonheim, Rhenish Hesse, are orbicular to ovate-oblique shells. They are moderately deep, with the surface concentrically ridged, the flats of the ridges being radially striate. The inner margin is flat, but crenulate on the inner edge. Again, examples from the White Crag (Lower Pliocene) of Orford, Suffolk, England,

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1 "*Arca aurita*," Brocchi. Conchiologia Fossile Subapenninae, 1814, p. 485, pl. xi., fig. 9.

2 In some specimens of *L. insolita*, between the brephic and neanic stages the shell undergoes a change in outline from a broad, semicircular to a decidedly oblique form. This imparts a subtrigonal aspect to the earlier half of a full-grown shell, but not to such a degree as in Brocchi's type of *L. aurita*.

are somewhat similar in shape to the preceding, but are smaller, and rounder in outline. The shell is also radially striate, as in the European Oligocene specimens. In these Pliocene specimens the inner margin of the shell is smooth, in this feature differing from the older, Oligocene, examples mentioned above. In this minor character it agrees with the Southern Hemisphere type of shell.

It is probable, judging from the above comparisons, that both Broochi's and Sowerby's specimens were somewhat worn, since typical shells of both species from type localities show the radial striae. Taking the evidence as a whole, there is good ground for regarding the Northern and Southern types as distinct; *L. aurita* being a rounder form, with simple striae or radial punctae, on the concentric rugae.

The Identity of the Southern Forms of the "aurita" type with L. insolita.—The most important distinctive feature between the Northern and Southern forms of the "aurita" type of *Limopsis* is the nature of the radial striae. As seen in the Victorian (Spring Creek) specimens, and also verified in the New Zealand (Oamaru) shells, this radial striation is complex, the sides of the pits producing a secondary and divergent series. McCoy[1] refers to it as follows:—

"Well-preserved specimens show under the lens close, obtuse, radiating striae, about twice their thickness apart on the flat portion of the concentric laminae, each seeming to widen and dichotomise towards the edge, which it does not pass (about 10 in 1 line at 3 lines from the beak)." By reference to Plate LXXXV., Fig. 11, it will be at once seen that this divergent striation is due to the effect of the pitted ornament. This peculiar character of the pitting is not seen in the European shell, *L. aurita*, which has simple striae equally spaced with the concentric rugae, and consequently imparting a tesselated appearance to the shell-surface.

The Victorian, South Australian, Tasmanian, New Zealand, and Patagonian specimens of this type, tested by the above and the other characters mentioned, are thus seen to belong to *L. insolita.* The originally described examples came from the

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1. Loc. supra cit., p. 23.

Santa Cruz beds of Patagonia. To settle any disputed points as to the relationship of our Victorian (Janjukian) species, the writer has been helped by the kindness of Mr. Chas. Hedley, the Assistant Curator of the Australian Museum, who has presented to the National Museum collection a typical example of the shell from the same series whence the original type was obtained. Sowerby, in his description of *L. insolita* says,[1] it is "smooth on the outside, and destitute of radiating ridges." The Santa Cruz specimen to which I have referred shows, however, that the shell is relieved by concentric lines of growth, and these are crossed by faint, but undoubted incised radii, which are more pronounced on the edges of the growth-lines; and on one part, on the posterior angle, the pseudo-divergent character of the striae is visible.

The New Zealand specimens, of which we also have examples in the Museum collection, bear the same characters as stated above. Zittel's specimen seems to have been a particularly smooth one, as, in describing this shell in his "Fossile Mollusken und Echinodermen aus Neu Seeland,"[2] he says:—"Die Aussenseite trägt keine Radialstreifen oder Rippen, ist fast glatt und nur mit einer schwachen concentrischen Zuwachstreifung bedeckt."

To give some idea of the prevailing confusion in regard to the identity of specimens of this genus by later authors, we may mention that Prof. Tate quotes McCoy's determination of *L. aurita* for the specimens from Mornington, and his own, from Muddy Creek (at neither of which places, by the way, does it occur); Bird Rock (McCoy) and Table Cape, Tasmania (R. M. Johnston). Further, under *L. insolita* in the same work, Tate correctly gives the localities of Aldinga Bay, Adelaide Bore, New Zealand and Patagonia. Another author, G. F. Harris refers specimens from S. Australia and New Zealand to L. insolita[3]; whilst on p. 346 of the same work he records *L. aurita* as from the Miocene of Awamoa, New Zealand, a typical locality for *L. insolita.* With reference to the latter species he remarks—"There appears to be no conchological difference between the European and Australasian examples of

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1 Loc. cit., 2nd ed., p. 608.

2 Reise der "Novara." Geol. Theil., vol. i., Abth. ii., 1864, p. 48.

3 Cat. Tert. Moll., Brit. Mus., pt. i., Australasia, 1897, p. 344.

this variable species. Typically the shell is not so oblique as *L. belcheri;* radial lineations are barely perceptible (or absent) in many individuals."

Distribution.—In Messrs. Dennant and Kitson's List of Victorian, S. Australian and Tasmanian Fossils previously referred to, the records under *L. aurita* Brocchi ? are Glen Aire, Shelford, Corio Bay, Table Cape and Beaumaris; and in a footnote (loc. cit. p. 122) the species is stated to be "probably a synonym of *L. morningtonensis.*" In the Dennant collection that author has referred examples from these localities to the latter species. In the present author's opinion, from an examination of those shells, they are referable to *L. insolita,* with the exception of those recorded from Beaumaris, which are typical *L. beaumariensis,* and from Shelford, where they appear to belong to *L. maccoyi.*

Balcombian.—Corio Bay.

Janjukian.—Aldinga; Lake Alexandrina; Ninety Mile Desert; Table Cape; Spring Creek (Torquay); Brown's Creek; Glen Aire; Cape Otway; Hamilton Creek; Aire Coast; Birregurra; Maude.

Synopsis of Distribution.

L. morningtonensis, Pritchard	Balcombian. Moderately common; typical.
L. maccoyi, sp. nov.	Balcombian. Common; typical. Janjukian. Rare. Kalimnan. Moderately rare; passing into L. tenisoni (living).
L. multiradiata, Tate	A very restricted modification of *L. maccoyi*; confined, so far as known, to the Lower Aldingan series (Janjukian).
L. beaumariensis, sp. nov.	Barwonian (probably Janjukian). Not common. Kalimnan. Typical and common. Apparently an intermediate link between *L. maccoyi and L. insolita.*
L. insolita, G. Sowerby, sp.	Balcombian (high in series). Janjukian. Throughout the series and typical. No characteristic specimens seem to occur in the Kalimnan series.

Remarks on the Phylogenetic Relationships of the Australian Species of Limopsis.

L. cancellata, Reeve,[1] from Queensland, has a surface-ornament approaching that of *L. beaumariensis*, but in outline the shell is equilateral as in *Glycimeris*, instead of subtrigonal.

L. tenisoni, var. *penelevis*, Verco,[2] is evidently a descendant of *L. morningtonensis*, Pritch., but with a larger and heavier shell.

The young shells of *L. tenisoni* are closely comparable with the young (neanic stage) of *L. maccoyi;* the distinctive characters not predominating until the brephic stage.

L. vixornata, Verco,[3] is of the *L. morningtonensis* type of surface ornament, but its shell is more equilateral and depressed.

L. eucosmus, Verco,[4] appears to have descended from *L. insolita*, with which it agrees in the contused ornament, with pseudo-divergent striae. This character, by the way, is not very distinctly shown in the original figure. Its outline is sub-orbicular, as distinct from the sub-trigonal to oblique shell of *L. insolita*. We thus have in the past and present Australian fauna the following types as distinguished by their surface ornament:—

Ornament.	Fossil.	Recent.
Pectinate	*L. morningtonensis*	*L. tenisoni*, var. *penelevis* *L. vixornata.*
Fimbriate	*L. maccoyi*	Young of *L. tenisoni.*
Malleate	*L. insolita*	*L. eucosmos.*
Cancellate	*L. beaumariensis* (also *L. aurita*, Brocchi, sp. of European types)	*L. cancellata.*
Latestriate	———	*L. tenisoni.*

In concluding these notes I would express my sincere thanks to Mr. C. J. Gabriel for invaluable aid in regard to typical recent specimens.

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1 *Pectunculus cancellatus*, Reeve, Proc. Zool. Soc. Lond., 1843, p. 188. Id., Conch. Icon., 1843, pl. vii., fig. 39.

2 Trans. Roy. Soc. S. Aust., vol. xxxi., 1907, p. 218, pl. xxvii., fig. 5.

3 Ibid., p. 219, pl. xxvii., fig. 1.

4 Ibid., p. 219, pl. xxvii., fig. 2.

EXPLANATION OF PLATES LXXXIII.—LXXXV.

Plate LXXXIII.

Fig. 1.—*Limopsis morningtonensis*, Pritchard. A group of three shells, showing interior of left valve and exterior of left and right valves. Balcombian Series; Fyansford. (Dennant coll. Nat. Mus.)

Fig. 2.—*L. maccoyi*, sp. nov. (= *L. belcheri*, McCoy, non Adams and Reeve). A group of shells showing interior of left valve, and exterior of two other left valves. Balcombian Series; Grice's Creek, Port Phillip (Coll. of Geol. Surv. Vict. in Nat. Mus.)

Fig. 3.—*L. tenisoni*, T. Woods. Interior of left, and exterior of right valves. Living; dredged from Western Port Bay. (Coll. C. J. Gabriel.)

About natural size.

Plate LXXXIV.

Fig. 4.—*L. multiradiata*, Tate. Exterior of right valve. Janjukian Series; Aldinga. (Dennant coll. Nat. Mus.)

Fig. 5.—*L. insolita*, Sowerby sp. The three upper figures, interior of left valve and exterior of right and left valves, are from the Janjukian Series of Bird Rock, near Torquay (Geol. Surv. Vict. Coll. in Nat. Mus.). The lower figure is a left valve in the gerontic stage, from the same series at Aldinga, S. Australia (Dennant coll. in Nat. Mus.).

Fig. 6.—*L. beaumariensis*, sp. nov. (= *L.* cf. *forskali*, Tate non Adams). Interior of right valve in gerontic stage and exterior of two left valves in gerontic and ephebic stages. Kalimnan Series; Beaumaris Cliffs. (Coll. of Geol. Surv. Vict. in Nat. Mus.).

About natural size.

Plate LXXXV.

Fig. 7.—*L. morningtonensis*, Pritchard. Surface ornament taken at 4 mm. below umbo. The shell is probably between the ephebic and gerontic stages. Balcombian Series; Fyansford (Dennant coll.).

Fig. 8.—*L. maccoyi*, sp. nov. Surface ornament from 15 mm. below umbo. Shell in the ephebic stage. Balcombian Series; Grice's Creek (G.S.V. coll.)

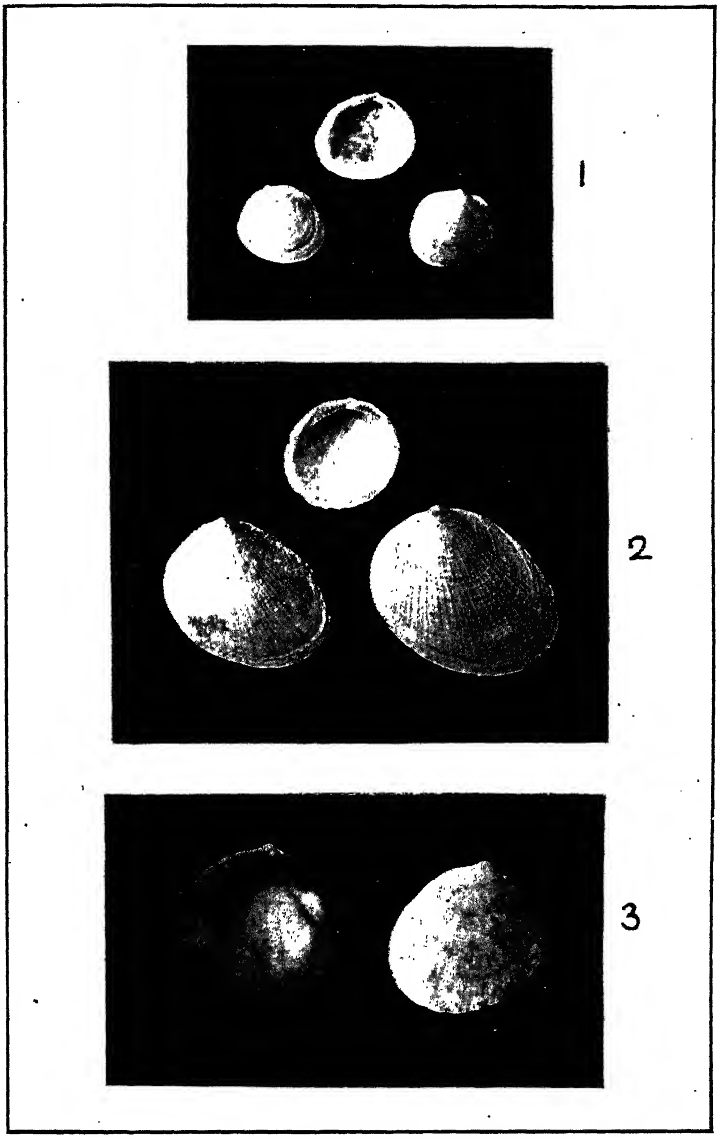
Fig. 9.—*L. tenisoni*, T. Woods. Surface ornament from anterior slope of valve in the ephebic stage. Living; dredged off S. Australia. (C. J. Gabriel coll.)

Fig. 10.—*L. multiradiata*, Tate. External surface ornament. Janjukian Series; Aldinga, S. Australia. (Dennant coll.)

Fig. 11.—*L. insolita*, Sow. sp. External surface ornament from middle of a right valve in the ephebic stage. Janjukian Series; Bird Rock Cliffs, Torquay (G.S.V. coll.)

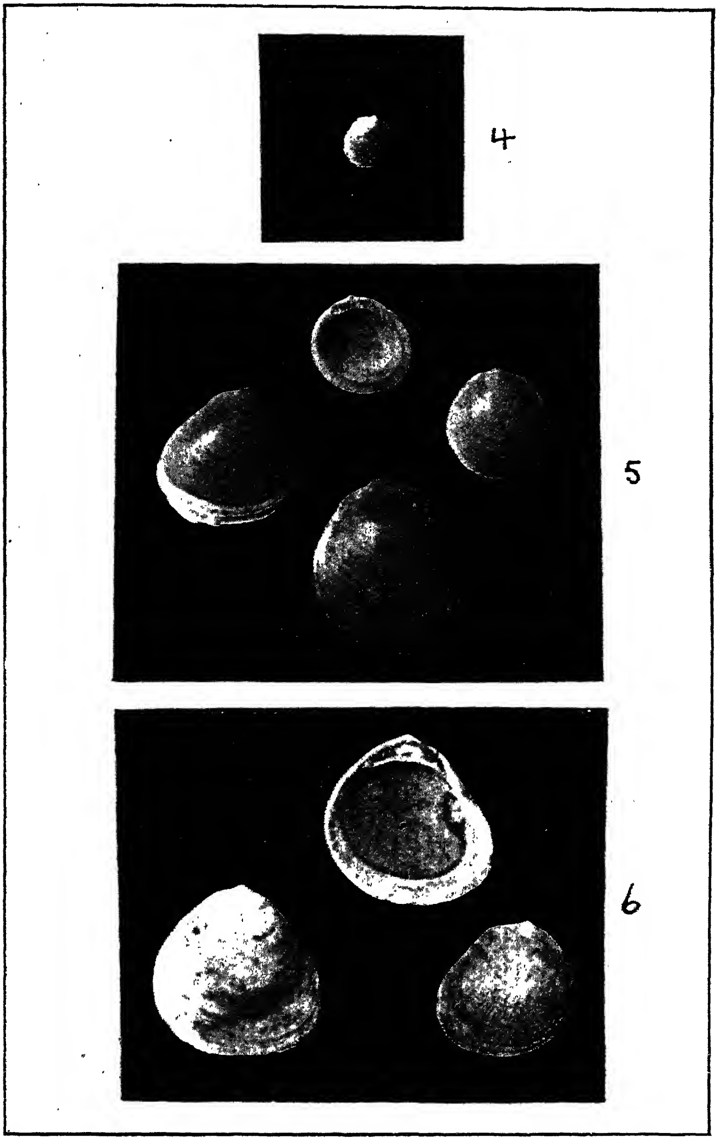
Fig. 12.—*L. beaumariensis*, sp. nov. Surface ornament from middle of valve in the ephebic stage. Kalimnan series; Beaumaris Cliffs, Port Phillip. (G.S.V. coll.)

All figures magnified 9 diameters.



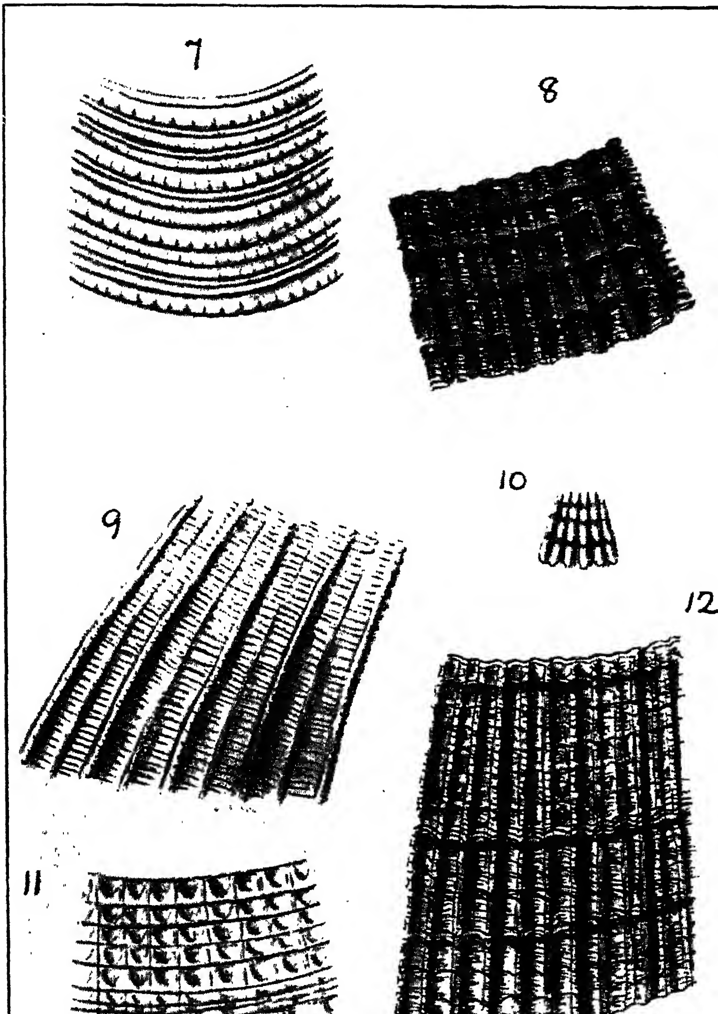
F.C. Photo.

Limopsis morningtonensis, L. maccoyi and L. tenisoni.
(About nat. size).



F.C. Photo.

Limopsis multiradiata, L. insolita, and L. beaumariensis.
(About nat. size).



F.C. ad nat. del.

External surface-ornament of Fossil and Recent Australian Species of Limopsis. × 9.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. II., 1911.]

Art. XXXIV.—*The Aborigines of Lake Boga, Victoria.*

By A. C. STONE.

[Read December, 1910.]

(Communicated by Professor W. Baldwin Spencer).

The following pages contain matters relating to the manners and customs of the above interesting tribe gathered by me during a residence of over eighteen years.

When I took up my residence at Lake Boga, no mallee had either been cut or rolled down, and the Murray flats were but very sparsely occupied, but I was immediately struck with the local evidences of a one-time large population of aboriginals, and I determined as far as it lay in my power to collect all the information I could first hand, as I was, unfortunately, forced to the conclusion that if it was not done then it would be impossible later on, in consequence of the ravages of the fell destroyer. At that period there were very few full bloods in the district. The last full-blood of the Lake Boga tribe was Hamilton Orr ("Nyarramin"—Worker in pine resin), the son of Booratchwornin (I won't listen to you), who was the son of Laremburnin (Pectoral Rail), the last real headman or chief, who died about 1830-40. He lies buried in the north-west bank of Lake Boga, and I have, fortunately, obtained what I believe to be his flint tomahawk, which was found buried with him. The last wizard or doctor (Barngnull) was named Cowanderning (creeping), and I have some of his charms, or magic stones of office. Hamilton Orr (Nyarramin) was, unfortunately, drowned in the lake owing to his boat being capsized by a sudden squall on March 7th, 1896. His body now lies at rest in the Lake Boga Cemetery. The expenses of his funeral were met by voluntary contributions, and I had the melancholy satisfaction of uttering his funeral oration.

The Lake Boga tribe was known as the "Gourrmjanyuk" (along edge of trees), a distinct section of the "Gnarryboluk" nation, which included several Mallee sections or tribes, and spoke a dialect called Wamba (No). The chief camping-ground of the Gourrmjanyuk tribe was around Boga township

(Muymer), and the various lake banks near by, and on to the banks of the Little Murray (Barne Mille). This camping ground was originally occupied by a tribe called Buck (Cat-fish), Language "Burapace," which had become extinct so long ago as to have left no trace except the tradition.

In this district there are hundreds of their cooking ovens or middens, some of them of very large extent, and containing hundreds of yards of burnt earth and ashes, and freely mixed with it are the remains of mussel shells and bones, with a very occasional chisel, tomahawk or grinding stone; and in rare instances an aboriginal skeleton has been found when these ovens have been ploughed over or removed, but I do not think that the practice of burying a deceased member of the tribe in an oven was often resorted to.

It is a thousand pities that these interesting and child-like people have had to go down and out; but there was no help for it—the vices and ways of living of the white man too easily corrupted the simple natures of the native inhabitants of the soil, and the result will be that in a very few years there will be no full-blooded Victorian aboriginal living. The law of "the survival of the fittest" has been ruthlessly obeyed in their case. It is not an easy task to get behind the aboriginal mind and to gain his entire confidence; he has an inveterate hatred of being laughed at, and is very suspicious of one's interest, but having gained his confidence it becomes surprising to find the vast knowledge possessed of the flora and fauna of his surroundings, and the tales and sometimes weird traditions of his tribe.

I have always met with courtesy and gentleness from these poor maligned folk, and have not the slightest hesitation in saying that any "native outrage" has always owed its origin in the misdeeds of the invaders. One white man may have had to suffer for another's fault, but the white man has always been at fault in the first place.

Designation of Tribes in Lake Boga tribal language (Wamba), including Gnarryboluk.

Boga Tribe	Gourrmjanyuk (alongside edge of trees), originally Buck (Catfish tribe). Language Burapace.
Warracknabeal Tribe	Yarrambeyook.
Avoca Tribe	Yang or Lunyingbirrwurrkgooditch.
Towanninny Tribe	Mallenjerrick (Mallee people).
Albacutchya Tribe	Gnallbagootchyourl.
Reedy Lake Tribe	Moorta moorta.
Wimmera Tribe	Jarrung jarrung.
Horsham (Mt. Albert) Tribe	Dallundeer.
Swan Hill Tyntynder Tribe	Dacournditch (Burrea dialect).
Mellool Tribe	Geroung bukeer (Always in fight).
Dimboola (Hindmarsh) Tribe	Cockleboeyill?
Gonn Tribe	Deitchen Balluk (Always shifting).
Euston Tribe	Jungeegatchera.
Bael Bael Tribe	Bael baelurnditch.
Hindmarsh Tribe	Gourballuk.
Gunbower Tribe	Gunboweroouranditch goole.

Localities.

Lake Boga	Muymer.
Lake Boga district	Gourrm (breast of woman).
Lake Baker	Boomberdill.
Lake Mannoar	Mynyungworl.
Lake Charm	Tcharm
Lake Hindmarsh	Gourr (Balluk tribe).
Lake Albacutya	Gnallbagootchya.
Long Lake	Towan.
Round Lake	Koonat koonat (lot of cotton weed).
Dry Lake	Chalkull.
Kangaroo Lake (Murdering Lake)	Dinger.
Reedy Lake	Bingerumbert.
Lake Tutchewop	Goutchewop.
Swan Hill	Marderucpert.
Tyntynder	Gingingerrett.
Boga Railway Station	Gourrk (Blood).
Boga, Cornish's hill (road)	Cooangetch.
Boga, Cornish's hill (bank of lake)	Nerrim nerrim (Steep bank).
Boga, Lake entrance	Wherpook (Where butt of gum fell).
Boga, Davie's swamp	Geranyuk (When leaves and branches fell).

Boga, Stewart's	Tdunooldarwin nung boolutch (Leaning trees).
Boga, Peppers	Wharparr (Willow trees).
Boga, 1st Hill to Swan Hill	Wooranden-o-Ghenguunee.
Boga, Davie's hill	Doornum (Deepest basin of lake).
Boga, A. C. Stone's	Yendchemile.
Boga, Long Lake Hill	Newrungl.
Boga, Fish Point	Gerrt.
Pental Island	(Nyetnyetpert). (Homestead). Bukarook (between rivers).
Murray	Mille.
Murray, Little	Barne.
Goschen	Gallallaban (Major Mitchell cockatoo's home).
Nyah	Nyeer.
Lalbert	Queywebeeul (Dry timber).
Mystic Park	Wallert.
Kerang	Keranyuk.
Charlton	Barn Barn.
Wycheproof	Wycheboorp.
Vectis East	Yowembull.
Avoca	Yang.
Heaven	Derrell (Above).
Hell	Gandagalough (Down below).
Tyrell Lake	Derrell.
Earth	Gar.
Haye's land (M.C.)	Darnoowongatch (Nyarramin's uncle shot there).
Sharams (granite outcrop)	Gorrouwonggnetch (Grief).
Richardson River	Barnunung (Smouldering away).

Personalities.

Full-blood - Last recognised Boga Chief (about 70 years ago)
Laremburnim (Pectoral rail)

" - Last recognised Boga Chief's Son
Booratchwormin (I won't listen to you)

" - Hamilton Orr, Grandson
Gnarramin (worker in pine resin)

" - Last recognised doctor (90 years ago)
Cowanderning (creeping)

" - Jacky Logan (Avoca)
Walpanumin (burning with fire)

" - Mary Ann Orr, or Logan (Avoca)
Boolkjallegook (smooth-tongued)

Half-blood	-	Jackson Stewart (Boga)
		Wirremander (whistling of spears, etc.)
,,	-	Ivanhoe Stewart (Boga)
		Jallerbamaritgournditch (thickly timbered)
Half-blood	-	Rob Roy Stewart (Black Cockatoo) (Boga)
		Barradapgournditch
Full-blood	-	Harry Fenton (Warracknabeal)
		Jourett
,,	-	Charlie Napier (Warracknabeal)
,,	-	Archie Pepper (Pelican) (Abacutya)
		Willeminger (the lost one) Millemurning
,,	-	Jacky Patchell (Reedy)
		Bokoplatt
,,	-	Harry Fenton (Reedy)
		Gippergournditch
,,	-	Tommy Fenton (Reedy)
,,	-	Charlie Cable (Gonn)
		Watterhine
,,	-	Sandy Cameron (Mellool)
		Margere
,,	-	Jack Irvine (Pelican) (S.A.)
,,	-	Last Chief (Wimmera)
		Joujoumon
,,	-	Last Chief (Horsham)
		Gorrundumin
,,	-	Last Chief (Euston)
		Jooliap
,,	-	Last Chief (Bael bael)
		Joley
,,	-	Anthony (Carr's Plain)
White people		Booleymer (Red face).

Relationships.

family	geithouwill bambonga.
child	boohoop.
girl (14 to 16 years)	gorrykurk.
girl (16 to 20 years)	gunge gourrm gourrk.
woman	leyurk.
wife	mathoom.
wife, my	mathoomy.
wife, his	mathamook.
mother	baap.
spinster	mookurnditch.
aunt	gnalluk.
widow	gootchall donna gourek.

mother-in-law	gnalling gourrk.
daughter	maangeeyp.
sister (younger)	gootoowee.
sister (older)	tchagee.
niece	gnoonaghun.
grandmother	meem.
grandmother, great	barrim gourrk.
boy (4 to 8 years)	boyangoo.
boy (8 to 14 years)	koolkurn.
boy (14 to 20 years)	boolyworrl.
son	waathip.
nephew	ghenanitch.
man	woodshoo.
father	maam.
father of dead son	mooka jup.
husband	gnunitch.
bachelor	corrioibert.
widower	gootchall doomough.
brother (older)	wawon.
brother (younger)	coot.
uncle (mother's side)	charrambowie.
uncle (father's side)	gnark.
grandfather	barrim.
grandfather, great	barrimbee.

Offices, etc.

chief or headman (small local tribe)	gnernick gnernick.
doctor or wizard	barngnull.
doctor, or wizard, if many together	barn barngnull.
message carrier	wyrkerr.
friend	gethoulie.
enemy	yowerek.
devil	gnatha.
god (our father up above the sky)	mamung mooruk.
good spirit	dallcook boonganditch.
bad spirit	yathung boonganditch.
soul	challewudchup.
sleepy head	coombybourrp.
coward	barnbymum.
liar	mapillawill.
chief or headman (practically king several local tribes)	marruk marrung gnooruk.
dwarf	wyngendap.
giant	yere goranduk.

Anatomical.

skin	meetchuk.	leg	boorap.
head	bourpook.	hand, fist, claw	munna.
eyes	merr.	thumb	baarpmunna.
chin	bomgunne.	finger, 1st	yullup yullup.
jaw	mooruk.	finger, 2nd	maarungle.
nose	gaa.	finger, 3rd	barkaminundup.
tongue	jolley.	finger, little	doonup.
teeth	leeah.	finger nail	lerymunna.
lips	wooral.	toe nail	lerygenna.
ears	woorinbull.	broken limb	callpine.
temple	tdoocutch tdoocutch.	small cut	cootchull.
		festering wound	booychun.
forehead	gnny.	sinews	ginnert.
mouth	jarrup.	flesh, fish (enemy)	yower(ek)
hair	gnarra.	tear	carthin merr
beard	gnunee.	tears	carthin merr nook.
moustache	munyeworra.	feather	wudthen.
blood	gourrk.	tail	berrcook.
bone	marderook.	kidney	baathun.
throat	gorrun.	kidney fat	marmbool.
chest	chung.	wrist	murk munna.
stomach	billee.	wing	tart thuk.
buttock	moom.	intestine (large)	barp goona.
breast (woman)	gourrm.	corpse (hollow, no life left)	jaark.
heart	weechup.		
waist	wanna.	afterbirth	barretch.
hip	mulloo.	nostril	wooiltchgaa.
armpit	caththup.	shoulder	tdarther.
elbow	moinyurk.	fin	gerring gerringyuk.
lungs	larenyow.	palm	jungmunna.
private (male)	berreck.	cheek	murragook.
private (female)	boot.	calf	joulook.
stone	boon.	hip	moola.
knee	baathin.	waist	wirmanduk.
ankle	meerk.	heel	connuk.
foot	genna.	thigh	wert corrip.
arm	taatuck.	phlegm	gaecoolegewin.

Ailments.

silly (head gone wrong)	yathungiah bourpook.
mad	yallung yallung.
rheumatism	cummuck cummuck.
toothache	catchelung leeah.
earache	catchelung woorinbull.
sore all over	jallum jallum.
shivering	jerimbiah.

cold	boonduning gneela.
headache	luliah bourpook.
dysentery	jurtee jurtee.
sunstroke	lalungen bourpook gnowie.
snakebite	boondin gourmillo.
paralysed	mulkilawill.
deformed	mulkilen.

Surgical and Medical Treatment.

In the case of a person being bitten by a venomous snake, the only treatment consisted in a very vigorous pinching and sucking of the bitten portion, which is believed to have always had the desired effect, provided the treatment was immediately put into practice.

The general treatment for wounds consisted in the application of a plaster of wet red pipeclay, bound on with opossum fur rope, and this rough and rude treatment met with general success, perhaps owing in a great measure to the healthy outdoor life led by the aboriginal.

In the case of headache and toothache (which occurred very occasionally), no treatment was applied, and the ailment naturally passed off.

Blood-letting was sometimes practised, and was carried out by sawing an opossum fur cord backwards and forwards over the spot from which blood was desired.

Of course in most ailments the doctor was the chief person officiating, and managed to imbue the patient with his great ability.

Most sicknesses were believed to be the result of evil machinations of enemies, and no person died of any sickness (old age excepted) that was not caused by enemies.

Steam Bath ("Burree").

When all other remedial measures for the cure of an obstinate sickness had proved of no avail, the last resort was the steam-bath—"Burree." This bath was prepared by making a large fire, and after it had burnt out the ashes were raked away, and a piece of bark was laid over the heated spot, a thick layer of mistletoe bushes and leaves were heaped upon it,

and then the patient was rolled in an opossum rug and laid upon the bushes. A profuse perspiration was generally induced, which often had the effect of greatly improving the condition of the patient.

The remedy quoted by Mr. P. Beveridge in his book on the "Aborigines of Northern Victoria and Riverina," and written in Latin, is substantially true of the "Gourrmjanyuk," and was absolutely believed in.

Weapons.

all throwing spears	jarrum.
reed throwing spears	jarrk jarrum.
mallee throwing spears, short	bukup jarrum.
mallee throwing spears, long, 9 ft.	werrego jarrum.
quartz jag throwing spears	woorawill jarrum.
reed jag throwing spears	ginhutditch jarrum.
fish spear	mool.
stabbing spear, 1 barb	queyun.
stabbing spear, 2 barb	booletch kawle queyun.
stabbing spear, 3 barb	booletch bar kiap queyun.
stabbing spear, 4 sets 3 barb.	dillwill kawle queyun.
throwing stick	corrick.
spear shield	gurrum.
waddy shield	mulkerr.
boomerang	wan.
boomerang, playing	widthewill wan.
strangling noose	wooren.
waddy, large	gnunnee.
waddy, yam stick	doolo gnunnee.
waddy, large three sided	weetch weetch gnunnee.
waddy, mushroom headed	ghen gunnee.
waddy, small	berpen.
waddy, boomerang	leahwill.
waddy razor edge	bolliyarrung.
waddy, spear point	goolurt berpen.
waddy, four sided.	gnatwill gnunnee.
waddy, woman's (covered with porcupine quills, and poisoned)	gnillgullk.

Implements.

dental instrument	waathun.
scraper	dang dang.
netting needle	burt burt.

chisel or knife	waatun
canoe	younggouitch.
canoe paddle or stick, no prongs	marrung.
yam stick	gerange gnunnee.
basket	meechat.
net	jaal.
poison bag (doctor's charm bag)	neil gnoonye.
bone awl	gurrning.
loop on stick snare	gnoortim gnoortim.
tomahawk	derr.
fire sticks (saw)	wannup.
fire sticks (drill)	gielwurrk.
fire tongs	mattum.
grub extractor	nyannen.
leaping kangaroo	weetch weetch.
stone	laar.
quartz	baatch.
message stick	wortein calk.
nardoo mill	jerinyuk cotthup.
nardoo mill roller	boolpa jerinyuk laar.
tomahawk grinding stone	wallanjuk.
grinding stone (large)	gorraanduk.
grinding stone (small)	woodtheuk.
grinding stone (very small)	yeretheuk.
shell	lerrynook.
bier	daitchim.
gravel	drik drik.
sharpening stone	marrook marrook.
mussel shell grinding stone	marrook marrook.
spear rubber	bert bert.
kidney fat extractor	nynying.
3-prong paddle	warrangouroung.
artificial leech	morrum.
gill net	jaal.
seine or drag net (large)	goullk.
seine or drag net (small)	gnellin gnellin.
net peg	gunneneuk.

Ornaments and Charms, etc.

nose ornament	gnaalich.
nose distenders	gnilliger.
ring	wanman willa will.
loin covering	widtha gnooraitch.
necklace (kangaroo teeth)	leangye gorey.
necklace (cane grass)	gallil gnalich gorrun.

necklace (crayfish claw)	mannunyeuk.
headdress	gippook.
headdress (possum fur)	murrum.
doctor's charm or poison bag	neil gnoonye.
rain bringer charm	boonyenge murndar.
poison or evil charm	yauthung ja. kutch kutch.
danger charm	kutch kutch.
marriage charm	wooien laar.
keep away evil spirit's charm	jarrung jarrung.
possum rug (large)	wallun.
possum rug (small)	gnatook.
poison sticks	neil gnunnee.
curlew stone	moorpen whillo.
opossum skin drum	bilp.
time sticks	berracourt.
opossum fur arm rings	morrum.
ankle bushes	gerra.
oath stone or charm	yere laar.
doctor's corrick or wand	barngnull nyenying.
opossum string for drawing blood	morrum.
necklace (crayfish attenae)	nunga carkuk langungnook.

Materials.

water	cartthin.
food	bannim.
bark	meetchuk.
bark, thin	larcurt.
smoke	boort.
mud	beek.
ashes	burrie.
land	corruk.
salt	jingewah.
gypsum, white	calkee punyell.
gum, red	gourcootch.
pipeclay, red	challowill beek.
pipeclay, white	durrawill beek.
gum, myall	llil.
gum, pine, new (fuller's earth)	genumarrung.
gum, pine, old (spear gum)	beetchurring.
gum, dogwood (sugar)	cutlewaran.
nardoo seed	jerinyuk.
egg	merrk.
beetle deposit on shoots (manna)	lerp.
string	bartitch.
kangaroo sinew	ginnert.

fire wood	lertwill.
tomahawk stone (greenstone)	worrwawill cootthup.
red raddle	neuro neuro.
crayfish antennae	lanyeuk.

Plants.

rushes	gang.
rushes, root	gumbung
reeds	jaark.
ribbon weed	narrelle
grass	booitch.
grass, barley	bourne.
yam	meerwan
marsh mallow	goonatch.
porcupine	walloo.
nardoo plant	dullum dullum.
nardoo seed	jerinyuk.
salt bush	joullern.
salt weed	gourcutch.
needle bush	gin.
prickly pink blossom shrub	tchoup.
murray pine	marrung.
box	boolutch.
box swamp	boolutch.
gum, red	beeul.
gum, white	baapt.
mallee, water root	weeah.
mallee, large broad	dannoh.
mallee, broad leaf, stunted (white sand)	boonerdak.
mallee, small	mallè or borrung or bourwitch (dark wood inside.)
myall	yannup.
bulloak	gnarry.
sheoak	goolurt.
native willow	warpur.
dogwood	gnurrel.
box, white	meetcharrn.
lignum	garrun.
native pear	gnonitch gnonitch.
native cherry	yena det gourk.
quandong, red	gourrkgourrkcook warrawill beeticull.
quandong, yellow	challewill beeticull.
pigface	booyeup.

pigface, little	gerrpen.
ming	cootha (root and bark used as a drink—stupefying).
dillon	dillunge.
fruit or seed	jerinyuk.
rush root (old) (after water has gone)	wangull.
rush root (old) (after cooked)	boortitch (used as food), see food.
rush root (old) (after fibre)	jeerk.
wire rushes (growing round lakes)	boonjurt (used in the making of string).
nettle	durkey jallum.
bulrush	woorpert.
bulrush (deep green slimy water weed)	geilgill.
water lily (small yellow)	billerm.
water lily (large)	weetchurrum.

Insects, etc.

centipede	ginuewarruk.
scorpion	widthagumma.
cricket	teetreetborun.
flies (small)	beetthick.
caterpillar (gum sawfly, on ground)	weeit.
butterfly	ballum ballum.
wattle goat moth	eurobill.
wattle goat moth, root grub (mallee).	gurr.
wattle goat moth, trunk grub (red gum)	gapong.
wattle goat moth, ground grub	mack.
wattle goat moth, carbuncle grub (box)	booloowong.
mosquitoes	leree.
midges	mongen mongen.
dry wood grub (no good grub)	dackal dackal.
caterpillar (sawfly grub, in clusters on tree)	gookul.
spider	werrinbool.
spider, red-backed	werrinbool jallawill.
ant, bulldog	leachwill.
ant, stinging	borrung.
ant, white	chuk chuk.
ant, large	maara.
ant, very small	boolabul.
flies (large)	bar beetthick.

Fish and Reptiles.

fish, flesh or enemy	yowerr.
mussel swamp	beitthin.
cod, Murray	byangill.
perch, Murray, 2 lb. to 3 lb.	werringill.
lobster, Murray	liplipkill.
crayfish, large	yappitch.
crayfish, small	nartung.
crayfish, soft	wallun.
leech, large	billitch.
leech, small	mann.
turtle	geehip or doomermum.
turtle, large	warangwor.
snake, worm	gnakungina.
snake, two hooded furina	mathamewa.
snake, tiger	goornmill.
snake, brown	ghallun.
snake, carpet (6 ft.)	beengull.
snake, carpet (10 ft.)	murndi.
snake, black	boychunwill.
snake, hoop	dickomur.
snake, mallee	moerwill.
snake, deaf adder	llerk.
worm	jourobillitch.
goanna, large	ghooling.
goanna, small	waattha.
frill neck	ghann.
lizard, small	tarramunder.
lizard, exuding	beepuntha.
lizard, sleeping	galleer.
turtle, broad shell	billwill larygnet.
catfish	buck.
frog, small	nunuk.
frog, large	dook.
frog, tree	merregur.
cod, murray (up to 1 lb.)	byangill byangill.
mussel, river (not eaten much)	nungerr.
cod, murray (very large)	gooroomeruck.
trout, murray	gnoomell.
perch, murray (large)	gerrek.
bream, murray	bipung.
herrings, murray	gnatty morrun.
blackfish	wooloornuck.

Birds.

swan	coonnoar.
pelican	nynungourk.
duck, black	nyree.
duck, wood	nannuck.
duck, blue wing	weetchut.
duck, teal	binnar.
duck, white eyed	garrut.
duck, widgeon	gewallert.
duck, musk	goolwil.
duck, mountain	gnarcoondull.
duck, speckled	gnall gnall.
coot, Australian	tdaich.
coot, bald	beenbing.
grebe, crested	gorrwong.
grebe, hoary-headed	gorrower.
spoonbill, yellow-billed	toop toop.
spoonbill, black	naangourelle.
cormorant, large	murtmurrel.
cormorant, little black	wallawalluk.
cormorant, little black and white	boourp.
darter	gercarthin.
dottrel, black-fronted	bert bert nalluk.
goose, magpie	gnak.
gull, silver	barpethen.
tern, marsh	garwit.
ibis, black	gnargourelle.
ibis, white	cukcuk.
black-tailed native hen	dallip.
stone plover	will.
plover, spur-wing	barretch barretch.
plover, black-breasted	munyuragurk.
stilt, banded	kercumbul.
native companion	gootthun.
turkey	gnarrow.
quail, little	bourongi; stubble quail, geichallert.
magpie lark	gerrin gerrin.
white-winged chough	mounyougell.
lyre bird	boolern boolern.
heron, white-fronted	carthinbung.
heron, white-necked	waan.
heron, nankeen	yapulyapitch.
heron, white	cathupbee mununderra.
bittern	coweer.
little crake	tillip.

pectoral rail	lerrup.
osprey	gamerillock.
wedge-tailed eagle	nurrayil.
crow	waa.
reed warbler	garcoon garcoon.
brown hawk	gercook.
harrier	birr.
sparrow hawk	yanuring.
kestrel	karra karrak.
cockatoo, pink (Major Mitchell)	kathukcurr.
cockatoo, sulphur crest (white)	geenup.
cockatoo, black	weerun.
cockatoo, rose-breasted (galah)	willick willick.
cockatoo, long-billed (corella)	gallalic.
parrakeet, black-tailed (smoker rock-pebbler).	gooren gooren.
parrakeet, rosella	gourk kallee.
parrakeet, shell (warbling grass)	tootther.
parrakeet, red-backed	gechurt.
parrakeet, yellow-vented (suloak)	billingurry.
parrakeet, mallee (ring-neck)	lumm.
parrakeet, cockatoo	wourep.
emu	goweer.
mallee hen	lowan.
magpie, black-backed	coorook.
brown kingfisher (laughing jackass)	gorrum gorrum.
black and white fantail	jerry kerrick.
butcher bird	garndoli.
welcome swallow	weetch weetch murrumbool.
brown tree creeper	been been.
swift	marder.
red-capped robin	jallegourk gourk.
friar bird	churrup churrup carthi.
noisy minah	brindeng.
blue wren	yeerelell.
brown song lark	gilpen gilpen.
bee eater	berrembert.
boobook owl	wook wook.
frogmouth	genykenitch.
powerful owl	werrymull.
owlet nightjar	yerradedgourk.
bronzewing pigeon	dapt.
crested pigeon	nungoore.
bell bird	doon.
harmonious shrike thrush	geiwoorn.

Animals.

porcupine	lipkill.
platypus	mabbeyull
kangaroo, dark-mallee, male	gowanyet.
kangaroo, dark-mallee, female	moitch.
kangaroo, plains, female	goowan
kangaroo, plains, male	burra.
kangaroo, silver-grey, male	goora.
kangaroo, silver-grey, female	moitche.
kangaroo rat	burre.
wallaby	gommah.
possum, silver-grey	wooleh.
possum, ringtail	bunnah.
possum, flying	doowan.
dingo	weelkar.
cat, tiger	youern.
cat, spotted	berrick.
water rat	gorambur.
mouse, ground, migrating	die.
spotted animal (liver and white), like a setter dog, living in burrows	lakletch.
pouch mouse	winnineuk.
horse	yarraman.
sheep	jumbun.
cow	youngamon.

Calculation.

one	kiap.
two	booletch.
three	booletch barkiap (2 and 1).
four	booletch booletch.
five	kiapmunna (one hand).
six	kiapmunna bar kiap.
seven	kiapmunna booletch.
eight	kiapmunna booletch bar kiap.
nine	kiapmunna booletch booletch.
ten	booletch munna.
small number	barthip barthip.
large number	weyoubarkarum.
uncountable number	munawitch.
and (in counting)	ba.
by-and-bye	gillaun.
long time ago	nuil mea goon.

last moon	munya mithreṇ weeken (last moon dead).
never	wambargunn.
pair	ginbill.
far	warritch.

Topographical features.

lake	chakill.
crabhole	taart.
spring or native well	berm.
river	gorange birr.
creek	woodthae birr.
track	baaring.
hill, also head	bourpook.
mountain	booinyule.
mountain, large	cowwa.
large camp	gorrunglur.
small camp	parnoolar.
native midden or oven	lukull.
cemetery or burying ground or graves	jemin jemin.
grave	jemin jemin.
whole country	meekmigarcombonbarcon.
gully	doomoan.

Colours.

striped	barnbundillawill.
spotted	bockool bockool warṛawill.
red	gourrkgourrkcook warrawill.
grey	durrawill.
brown	boonboonwarawill.
green	woorwawill.
yellow	challewill.
black	workerrim.
white	bullermouwill.
blue	boort boort warrawill.
slate	boonboonworrawill.
dark	goonajillawill.
very bright	bockwinyawill.

Climatical and Astronomical.

spring	gnalloo.
summer	carthi.
autumn	weit punyallow.

winter	weit.
north	barrewill (where the hot winds come from).
south	boiecalling darn (where the frost winds come from).
east	worwalling gnowie (where sun rises).
west	purticalling gnowie (where sun sets).
fog	goowa.
dew	cootchall.
day	gnowie.
night	boorung.
rainbow	darrakewoorlwoorl.
hurricane	gnanuk.
clouds, nimbus (rain clouds)	morren.
clouds, cumulus (wool pack)	dunbill.
clouds, flying scud (flying scud)	maarn.
blue sky	woorl woorl.
morning	barrep.
night	boorung.
wind	merring.
wind, cool	marrick marrick.
wind, hot and duststorm	pyrewill.
thunder	murrenderra.
lightning	willem.
rain	metthuck.
frost, snow, ice	darn.
whirling dust	gnarruk.
hurricane	wournmalle.
ice on water	denning.

Astronomical.

sun	gnowie
moon	mitthean.
star	durrt.
star, morning	generpkoonberp (pulling up daylight).
star, flying (meteor)	boieka durrt.
star, Venus	beerk or moolungurt.
star, Sirius	goorawill.
star, Pleaides	gorraitch gorraitch gourrk (several young women).

Prepositions and Pronouns and Adverbs.

if	gnunyamalloo.
perhaps	mambamalloo.
by	gunonaguenunda.
on	monga youma.
to	gneaull yannuk.
there	nung.
from	mongo.
here	neuka or karki.
inside	wichup larengull.
yesterday	challik challik.
to-day	keilanowie.
to-morrow	barrapoo.
theirs	geika gooleketch.
we	wallunganduk goola.
us	wallunganduk ghanna.
they	mynyou.
yours	wallukkaen.
ours	wallukkanduk.
me	wallunjek or ginya.
he is	yeuk.
you	wallungyin.
I	wallunjek.

Nouns.

songs	warrung warrung.
cut	cattoordin.
nest or home	lurr (shelter made of bark for winter).
nest or lowan's	moe.
birthplace	kinjajanyek.
home (my)	kinja larenyek.
ashes	burree.
oven or midden	cootthup.
fire hole	burree.
dirge	worpa.
drowned	goroungen.
murdered	garrickenbethen.
burnt	nungyen.
suffocated	nourken.
poisoned	yathungeja.
born	eurpeenek.
dead	weeakin.
funeral	nypjarrung.
smoke	boort.

"corroberee"	warreba.
fire	waanyup.
truth	yourook.
liar	beek.
heat	nunga carthi.
fog that killed (small-pox?)	yathungejah.
savage native or sneaking fellow	karpit karpit.
battle	boiemba.
duel	dockcharram boluh.
skirmish	gilcharrenitch.
small war party	barnburn.
large war party	barnge barnge.
virgin	joonge gorrum jourrk.
wound	werp.
branch	dartagook.
race	winnuk winnuk jarrung.
bird	watthebeyower.
divorce	winnejarrunbool.
dream	yakgooclun.
cripple	jowerwill.
noise	gneill.
milk	gourrmbook.
tea	gnamutch.
home or camp (bushes and covered at top)	gnark.
home or camp (travelling), shelter of bushes only, open at top	bourrk.
yes	eeah.
no	wamba.

Verbs.

to point	lit.	pointing	litkoonga.
to paint	uka.	painting	ukelung.
to pinch	jellerpa.	pinching	jellerpoowin.
to drink	coopa	drinking	coopen.
to rub	gorrunda.	rubbing	gorrundawa.
to roll	boolpa.	rolling	boolpoowa.
to run	werra.	running	werrwa.
to bury	gnippa.	burying	gnippelung.
to steal	cannunga.	stealing	cannungella.
to sleep	coomba.	sleeping	barrungoodthun.
to swim	werrakar.	swimming	werraken.
to sharpen	birta.	sharpening	litkoonga.

to slip	eureme.	slipping	eurema.
to speak	wirrika.	speaking	wirrakin.
to smoke	boort.	smoking	boortalung.
to shout	corndee.	shouting	cornder.
to smell	gnarropa.	smelling	gnarropelung.
to sneeze	chinangda.	sneezing	chinungdelung.
to sing	warranga.	singing	warrangelung (if many singing add utch).
to sting	birka.	stinging	birkoowa.
to strike	gilpa or docka.	striking	gilpoowa.
to scream	karker.	screaming	karkeria.
to smash	jallung jallung noonga.	smashing	jallung jallung gnoowa.
to make	mongen.	making	mongellung.
to open	bakoonga.	opening	bakoongelung.
to tie	gannuk.	(tying	ghanna.
to try	baathama.	trying	baathamoouk.
to taste	barthamuk.	tasting	barthamelung.
to walk	kalpurren.	walking	yannugh.
to wind	mooremba.	winding	moorema.
to warm	darrama or boorkia.	warming	darramelung.
to whistle	weita.	whistling	weitra.
to blow	boorungoouck.	blowing	boorungen.
to burn	dappok.	burning	dappelung.
to bite	boonda.	biting	boondalung.
to break	callpiah.	breaking	callpinah.
to bleed	birngooning gourcook.	bleeding	birnin gourcoomba.
to crawl	cowerndee.	crawling	cowernda.
to cry	neumillee.	crying	neumillung.
to cut	berringen.	cutting	berringelung
to climb	weerwa.	climbing	werrawee.
to cure	dalkoona.	curing	dalkoongoowa.
to cough	ganyunga.	coughing	ganyungoowa.
to die	weekin.	dying	weeka.
to dig	bunga.	digging	bungelung.
to eat	junga or chakalee.	eating	chakalung.
to fight	dockcharrung.	fighting	gilpjarrungutch.
to float	jippa.	floating	jippouen.
to fly	boika.	flying	boikawill.
to grind	birta.	grinding	gourrapa.
to hunt	barrayeah.	hunting	barrayeuh.
to hang	joolakar.	hanging	joolekoowar.

to hurry	werrkur.	hurrying	werrkoouk.
to hate	goolejoon.	hating	goolejoowa.
to help	nunga.	helping	nungarroungall.
to kneel	barthin bauthee.	kneeling	barthin bauthung.
to lose	wamboonging.	losing	wamboongawin.
to live	moorinie.	living	mooriniah.
to lie	coombe.	lying	coomba.
to laugh	waaka.	laughing	waken.
to lie	mapillewill.	lieing	maalpellung.
to marry	maanjerrywill.	marrying	wooyewin.
to kiss	moorpa.	kissing	moorpoowin.
to kill	barngoona.	killing	barngoonen.
to kick	karta.	kicking	kartin.

Adjectives.

sharp	litthiar.
wet	cootchall.
dry	burtia.
hot	gnunga or walpa.
thirsty	baarnkoongya.
hungry	weekan.
cold	mayrengemun.
warm to	beetchuka.
sweet (for sweeter add yere)	weeitcha weeitcha.
slow	wearia.
short	dooloo; shorter, dooloongyeuk; shortest, add yere.
tall	jouroung; taller, jouroung jouroung; tallest, add yere.
blunt	moort.
sick	catchelung or gillika.
weak	moolpiah or mikawill.
wild	barmbowill.
bald	birra.
left-handed	warrum.
right-handed	youelp.
squint-eyed	wilkelmer.
one-eyed	kiap mer.
ugly	yathung.
crooked	merme.
cruel	yathung.
fierce	gooleywoochup.
savage	gooleywoochup.
good	dalcook.
bad	yathungandook.

fast	boonwill or meelakwill.
high	kerrcutha.
low	goonagull.
light	wyma.
dark	borun.
lame	jowa.
small	widtheyook (smaller) bangook.
small, very	yerewidtheyook.
large	goorandook; larger, goorandookly; largest, add yere.
stupid	wam.
rough	boourk.
tired (I feel)	meekun.
fresh (I feel)	gippun.
blind	gorrun gorrun.
deaf	catchin nundagnauillung or wam-wum.
dumb	catchim wooraka.
delicate	marrun marrun.
married	woorenutch.
bloody	goourkcoomba.
empty	larnookum kinjawook.
old	nyarambin.
old, very	yering nyarambin.
young	gollcourn.
quick	warrcuk (for very quick repeat)
steep	neerinull.
strong	wongerwill.
stinking	boowong.
silent	goorungiah.
soft	boolk.
lazy	meekunda.
silly	mukelen.
mad	yathungeah bourpook (head gone wrong).
wise	bukieh book.

Sentences.

he will run	nunya wooring.
let her walk	ganerook nunya yannup.
how are you	wunyardall kinja.
good-bye or good-day	booyen.
you hurt me	catchil loongerring.
he struck me	dakinarnding.
they found these	mallogoole jarmin kinye.

I like you very much (nearest to love)	nyanga nunya leyurk wooithoo pourek.
I hate you	gooley joowannoo.
he, she, or those loves you, him, or they	nunyaboola nyacharrung.
he hates you	neula gooley joowan.
come with me	neuka yannuk wallo gallek.
go with him	yannuk wallo gallook.
go with them	moyu yannuk goolekal.
you can go	wallungen yannuk.
do not go	wamba yannuk.
I am going	yangin yunda.
I will stay	nyangin yunda.
let him stay	canerook nyanyup.
can I go fishing	win janda yarrowa yeringe leeah.
let me go hunting	yarrawonda barrayeuh.
the bird fled away	boykin yerelil.
the bird is flying	monga boykun yerelill.
the codfish is swimming away	baarnjill neeyon werrakun.
can you cook this flesh	nyapera kinya bowa yower.
cook that flesh	boytch amuck nunya yower.
eat this, that or those mussels	chakuk nunya beethin.
I cannot fly	catchin nunda booika.
you do it yourself	wallunken mathamuk.
good luck	mombunda bemmeleng.

Marriage.

The "Gourrmjanyuk" of Lake Boga tribal preparation for and ceremony of marriage was a very simple one. No marriage was allowed between blood relations, or between any member belonging to the same totem. For instance a Pelican would not be allowed to marry a Pelican, or a Black Cockatoo another of the same section, and so on. Every member of a tribe belonged to a totem, generally a bird. When a man of marriageable age desired marriage and had a female relative to exchange, word was sent to a neighbouring tribe that a daughter of that tribe was desired in marriage. The father of a marriageable girl (the future son-in-law was never allowed to see the future mother-in-law then or at any other time) with his daughter, and other relatives would meet the young man with his father and other relatives at a previously arranged

spot. The future wife would then (in exchange for some other female) be handed over to her future husband, and the two parties would separate, each going to their respective camps. Upon reaching the husband's camp a spot would be pointed out to the newly-married couple upon which the wife would erect the home, "Lerr," for the near future.

Should the wife not come up to the requirements of the husband he had the peculiar privilege of returning her to her people.

If a good hunter required a second wife, it was within his privileges to obtain another, provided he could keep her, and that he had a female relative to exchange. The position of the wife was a very lowly one. She had to build the hut, catch fish, cook food, make nets for hunting and fishing, sew opossum rugs and other multifarious duties. She was married early, and became old and ugly long before her time owing to the hard life she was forced to live.

Burial.

Upon the death of a member of the "Gourrmjanyuk" tribe, a shallow grave would be dug, generally in a sandy spot, to a depth of about two or three feet. The bottom of the excavation would then be strewn with grass thickly, and covered with a sheet of bark; then the body was wrapped in a rug and laid on the bark, upon its back, with the head generally in the direction of the setting sun. It was then covered with grass, and finished with a sheet of bark, and then the grave was filled in. In many cases the tomahawk and grinding stones of the deceased were placed at his side, and buried with him, and I have particularly noticed in the Boga district that the stones buried with the body are invariably chipped or broken right through. Although the above form of burial was generally the rule, I have this day (August 3rd, 1910), examined a burial ground near Lake Boga, the slope of the hill facing S.W., and on this slope, in sandy soil, are buried perhaps a score or more of aboriginals; the bodies of more than a dozen seen were buried in many positions. One lay full length upon its face, with the head to the S.W., at a depth of two feet. The body

would have been about 5 ft. 9 in. At its side was lying a broken tomahawk. Another body lay on its side, with legs drawn up. Another lay in a sitting posture, with the head perfectly upright. The heads lay in directions varying from E. round S. to W., and I particularly noticed that in every skull, whether a young person or a weather-beaten old veteran with the teeth worn down to stumps, that in every skull the teeth were all intact and absolutely round. Alongside one of the skeletons a broken piece of what was originally a magnificent specimen of a rubbing or pounding stone was found, a piece of flat, round, smooth buff sandstone, measuring 4½ in. by 8 in.

It is believed that these natives were killed by Major Mitchell's expeditionary force, which may or may not be true. Perhaps small-pox.

Fire-making by the Use of Sticks ("Wannup").

The method of making fire was a simple but most effective one; for the purpose two pieces of dry pine or other wood were obtained about 18 inches long. On the bottom piece a slight depression was cut in the form of a cross, the cut following the grain of the wood being deepest. The other stick was brought to an edge along most of its length. It was then placed in the cut across the breadth of the under stick, and very rapidly pushed back and forth as though sawing, which speedily produced charred dust, smoke, and then smouldering dust in the longitudinal cut, which was covered with dry bark or grass, and blown into a flame. Fire was made in other districts similar to drilling.

Barter or Exchange.

The various districts of Victoria producing various materials only found in its special district. It might be thought that other districts would be unable to obtain their requirements, but this was overcome by a system of exchange, as each tribe was forced to keep within its own prescribed boundaries.

For instance, the Boga tribe had no difficulty in obtaining any quantity of reeds ("Jarruts"), used for making reed

spears ("Charram"), which were exchanged for grinding and tomahawk stones or other raw material, which could not be found in the district, and which was necessary for hunting or decoration. In the Boga district large quantities of small pieces of quartz ("Baatch") are to be found, which were no doubt brought a very long way, and exchanged from tribe to tribe. These pieces of quartz were used to tip spears, and to form the jags, for knives and scrapers to scrape and carve wood, rugs, etc. Small pieces have been found with gold in them. The sources were possibly St. Arnaud, Bendigo and Raywood.

Canoes, and Their Use and Manufacture.

The district surrounding Lage Boga is peculiarly adapted to the use of canoes, in consequence of the numerous lakes in the locality, and the Little and big Murray Rivers. The Gourrmjayuk were adepts in the arts of fishing, and used nets of various patterns to effect their purpose, and of course canoes came in for the purpose of running the nets, and approaching fish-spearing grounds, also in the pursuit of native game on both land and water.

The canoe was made of one sheet of generally red gum bark, stripped from the tree by the aid of the native tomahawk and wedges. Two logs were then laid on the ground parallel and at a distance of a foot or two; two more logs were then laid across them parallel, and at the required distance; the sheet of bark was laid upon the logs, and a fire of paper-bark and grass was placed on the bark, for the purpose of curling up the sides and ends, and also to toughen the canoe for its future hard work; heavy stones were placed where required to help shape the canoe. This process was continued for perhaps a week, or until such times that the canoe conformed to the desires of the builder. The last process was the plastering of the whole of the inside of the canoe with clay or mud to render the whole waterproof. No seat was used, and the means of propulsion was either a flattened stick or the three-pronged paddle, which was also used for the purpose of locating fish.

The canoes varied in length from 5 ft. to 10 ft. and over, and carried from one to four men.

Lake Boga Aboriginal Legend to Account for the Treeless State of Lake Boga, and the Mournful Wail of the Stone Plover.

At one time, long years ago, there was a very large redgum tree growing in the lake, and its branches supported a tremendously large nest, the property of an immensely large pair of wedge-tailed eagles ("Nurrayil"). One fine day a young mother wandered, carrying her baby, a long way round the lake, and far from the camp, when, feeling tired, she sat down and amusedly watched her baby playing in the warm sand, when suddenly, and without warning, the larger of the two eagles swooped down and, seizing the baby, carried it away over the water to its eyrie in the red gum tree. The poor mother, seeing her baby suddenly lost to her for ever, commenced a mournful wailing, which the curlews or stone plovers ("Will") in sympathy took up, and have continued ever since. The disconsolate young mother then hurried back to the camp and reported the occurrence, upon which the doctor or medicine-man ("Barngnull") directed that every person with a canoe was to proceed to the tree, and after cutting it down to tear it into little pieces, and to boat it all away to the river, where it was to be thrown upon the water to be carried away. The doctor then decreed that no more trees should grow in Lake Boga. The tree in falling hollowed out with its branches a big depression near the river, which they called "Geranyuk" (where branches and leaves fell). The large gnarled lump on the tree trunk struck and hollowed out a big hole at the entrance to the lake, which they named "Wherpook" (where butt fell).

Destruction of Floating Island on Lake Boga ("Gourrm").

A long time ago ("Nuil mea goon") there was a floating island on the waters of Lake Boga. The native idea was that it was formed of a mass of rushes and reeds, on which the duststorms had deposited a stratum of sand, and in which grass grew. One day a number of young men were upon the island, and the day being a warm one they spent a lot of the time swimming. One youth, not being a good swimmer,

became exhausted, and in danger of drowning. He was rescued by his friends, and being then very cold and unconscious a fire was made to warm him, after which they went back to the camp. During the night a breeze sprang up and fanned the embers into a blaze, with the result that the reeds and rushes speedily caught fire, and the island was totally destroyed.

An Account of "The Fog that Killed," or "Poison Fog." ("*Yathunge jah.*")

Perhaps about 80 to 100 years ago a swiftly-killing disease (possibly small-pox) killed a great number of the members of the Boga tribe ("Gorrmjanyuk"). The idea was that it came like a fog, low-lying over the land. Up to a few years ago numbers of the skulls of the victims were to be seen round the banks of Lake Baker ("Boomberdill"), and the awful fear of the poison-fog lasted up to very recent years. (Natives say previous to small-pox.)

"*Gourrk,*" *or Battle of Blood* (Railway Station Site, Lake Boga).

Many years ago a very sharp bit of fighting took place on the site of the railway station at Lake Boga, between the Tyntynder and Boga tribes, and in consequence of the quantity of blood spilt it was called the "Battle of Blood," or "Gourrk."

The Lake Boga Aboriginal Legend to Account for the Redcap Robin's Redbreast and the Mountains of the Moon.

When the world was young, an aboriginal and his wife had living with them the little brother of the wife. The husband was a very greedy and selfish man, and very much grudged the food which the wife gave to the little boy, so much so that the only food the little fellow got was the scraps of meat surreptitiously given by his sister. One day the man came back to his camp sooner than he was expected from hunting, and discovered the boy nearly choking in his endeavour to swallow the meat before the husband should be near enough

to stop him. The husband was so enraged at this that he caught the boy by the legs and swung him round until he became sick, and then cruelly threw a lot of burning coals on his breast, upon which the boy turned into a "Jallegourk gourek," or Red-capped Robin, with a beautiful red breast. This outrageous treatment of the boy so much angered the sister that she in her turn threw a lot of hot coals over the face of her husband, and told him to go up in the skies, which he is supposed to have accordingly done, and become the moon ("Mitthean"), the mountains of which are supposed to be the dark smudge left by the hot ashes.

The Legend Accounting for the Formation of Lakes Hindmarsh, Albacutya and Wonga, also Werringurr.

Ever so long ago a big black spider ("Werrinbool") saw a little squirrel ("Doowan"), which he chased up a tree. The Werrinbool bit the tree until it commenced to fall, upon which Doowan jumped into another. This Werrinbool commenced treating as before, so Doowan climbed to another, with Werrinbool still in pursuit. As the last tree fell the Werrinbool seized poor Doowan and killed and ate him. Now Doowan had two nephews, who missed him sore, and determined to see what had become of him by tracking him down. They tracked him to an ant hill, where they found some of the Doowan's hairs, upon which they immediately suspected Werrinbool, and very soon found the first camp (Lake Hindmarsh). They passed along the track until they discovered the second night's camp (Lake Albacutya), with the ashes of the fire still warm. Still proceeding upon their way, they came to the third camp, with the Werrinbool's fire still burning. The oldest nephew directed the younger to go up against the wind for the Werrinbool to smell him, at the same time getting into hiding to lie in wait. The Werrinbool soon smelt him, and as he was creeping after the younger, the older nephew speared him, and the younger ran in and also threw a well-directed spear, and then the pair cut off the Werrinbool's head, and continued playing with it for some time by rolling it from one to the other, and that is how Lake Werringurr was formed.

The Legend Accounting for the Teeth-like Shingles of Lake Werringurr.

The old Werrinbool had two daughters, whom he left at his camp. The two nephews of Doowan, after killing Werrinbool, went back, and, finding them, they took them for their wives. They then all went a day's journey, and passing through some scrub came upon some kangaroos feeding. They told their wives to remain there for a while, whilst they went after the kangaroos and killed them for food. When they were near the kangaroos they heard a tree falling, and they wondered why, but when they got back to their wives they saw the fallen trees, and then they knew that it would not be wise to keep them as wives. So they said to them, "Let me put the bundles on your backs," and, as the wives, consenting, stooped down for the purpose, the brothers at a preconcerted signal struck the unsuspecting wives with their waddies ("Gunies"), and dashed out their brains and teeth and jaws, which accounts for the teeth and jaw-like shingles found at Lake Werringurr.

Kangaroo or Murdering Lake ("Dinger").

Many years ago a shepherd's hut stood at "Wherpoo" (where carbuncle on trunk of big redgum struck), the entrance to Lake Boga. One night the natives sought to obtain some cheap mutton by spearing, but the shepherds in charge (2) became alarmed, and, as was the custom in those old days, used their firearms to such effect that "Nyarramin's" uncle (Peter) was mortally wounded, and died, and was buried at "Darnoowongatch" (N.E. bank of Boga). The two shepherds were transferred to Kangaroo Lake, as it was feared that the natives would seek reprisals, but this even was of no avail, as the vengeance of the tribe overtook them. For one fine afternoon the two men, unsuspicious of impending danger, were sitting upon a fallen log, reading, with their firearms on the ground beside them, when without warning of any description they were speared to death. After the killing of the shepherds one of the natives nearly met his own death. He seized one of the guns, and dashing the butt of the gun upon the ground exploded the weapon, the charge going between the man's

legs, but without touching him. He received a great shock, and was the butt for their merriment for years. This incident originated the name of "Murdering Lake," which name it bore for many years.

The Legend of "Geiwoorn" (the Harmonious Shrike Thrush).

Once upon a time a young hunter named Geiwoorn had fixed his home or shelter of bark ("Lurr") at the foot of a leaning pine tree on a hill close to the Richardson River ("Barnunung," smouldering away). He had two very large dogs, of which he was very fond. These dogs were very useful to him, and he used to depend upon them to keep up the supply of meat. When the supply of food ran low a word only to the dogs sufficed to send them away by themselves on a hunting expedition, from which they invariably returned with sufficient to last for days. One day, the food running low, the hunter sent his dogs away as usual, but they did not return. For many days the young hunter used to climb up the leaning pine tree to look over the landscape, and to whistle for his dogs. Close to the tree there was a pit of pipeclay, and one day when the hunter was up the tree whistling for his dogs he saw a party of natives come to the claypit, and one of them asked him what he was whistling for. He replied that he was whistling for his dogs to come back, but to his great grief he was told that they would never come back, as they had speared them both. The young hunter then set fire to the pine tree at the roots, and it smouldered away, whilst the natives were decorating themselves for a corroboree. Some were painting themselves to represent magpies, black ducks, etc., when, without warning, the smouldering tree fell and killed them all. In a few days' time the poor young hunter died of grief and hunger and became a Harmonious Shrike Thrush ("Geiwoorn"), and has been whistling ever since.

Magic Stones or Charms.

The Boonyenge mundar, or Rain bringing stone, is a round, smooth stone, resembling white loaf sugar. It was placed in water when rain was required, and when sufficient had fallen

it was taken out, dried carefully, and placed away in the doctor's ("Barngnull") poison-bag ("Neilgnoonye"). Should, however, the rain be required to stop very soon, the stone or charm was dried quickly by the fire.

The Danger stone ("Yatching werrip werrip") or Kutch Kutch laar, is a smooth, oblong, flat blue pebble, and was used similarly to the Scottish fiery cross. It was passed quickly from person to person, and always pointing in the direction of the danger, until all the members had been warned of the impending danger.

The Marriage or Betrothal stone or charm ("Wooien laar") is a smooth, flat, blue pebble, smaller than the above, which was (after a proper examination of the female candidate for matrimony) given to her with the direction that it was to be placed in the armpit, and kept there by opossum skin bands until the consummation of the marriage.

The stone or charm to keep away evil spirts ("Jarrung jarrung") varies greatly in character from round pebbles to flat ones, and of any colour. They were buried with the corpse ("Jaark," meaning hollow, no life left). I have two that separated three corpses, one an oblong, dark, smooth pebble, originally possibly a pounding stone, the other round, smooth, flat, and yellowish in colour, and of no possible material use.

The curlew stones or charms ("Moorpen whillo") were supposed to have been smoothed in the stomach of a curlew or stone plover.

The oath stones or charms ("Yere laar") were of two sizes, and very irregular, composed of quartz, iron pyrites, etc. The larger was for the male and the smaller for taking the word or evidence of the female.

The doctor or wizard ("Barngnull") of the tribe would wrap the stone round with native silk or thread, leaving one end loose. The suspect was forced to hold the packet at the height of the mouth, and reply to questions asked. After the muttering of incantations the suspect would be seized by the wizard, or doctor, who would bite him and pretend, after a long process of sucking, to draw out of the man's body a small piece of stone, which he would spit out and show as proof positive of the culprit's guilt.

For a lesser crime the culprit would be assailed up to an hour by two or three natives with throwing spears, which he had much ado to stop to save his skin. If a man was deemed worthy of death a favourable opportunity would be seized for either spearing him to death, or dashing his brains out with a large waddy.

Poison Sticks ("Neil Gnunnee") and Their Use.

The poison sticks of the doctor, or wizard ("Barngnull") were, for the Boga tribe, three in number, made of the wood from the yellow-fruited Quondong tree. They were each about four inches long, half an inch wide, and were brought to a point on each end. They were rounded on three sides, and flattened on the fourth, with a little rough, mystic carving on the rounded portion. They were tied together with sinews or native string, and some portion of the condemned individual, or something that had been used by him, was placed in the centre. The whole was anointed with kidney fat. In some out-of-the-way spot the doctor dug a shallow hole, and after lighting the end of the sticks, covered the whole with bark, and then filled it in, carefully, so as to leave no trace of the place having been disturbed. The next day it would be opened up again and attended to, and so on for perhaps many days, the idea being to cause an infinity of suffering to the condemned person. By the time the sticks were completely burnt the culprit was supposed to be dead, and there is no doubt but that end would be attended to by the fiendish ingenuity of the doctor, possibly by the use of the throttling noose ("Wooren").

The Throttling Loop ("Wooren").

This fiendish instrument for the destruction of human life was made of long strands of sinews from a kangaroo's tail, joined together to the required length and plaited. Four of these plaits were laid side by side. One set of ends was formed into a loop, and the other ends were fixed to a pointed piece of kangaroo leg bone, the whole affair being about four feet long. The noose would be thrown over the head of the unsuspecting

victim, who would be speedily strangled without a cry. This instrument was well greased and coloured red. When a strangled victim was found, every person professed to be ignorant of the manner of his death. The instrument was always kept carefully concealed by the doctor (" Barngnull ").

The Lord's Prayer.

Wallukkanjoruk Marmongaruk monga eumon derrill luttha
Our Father up above the skies
Yeenyeendaditch eomip nyaringen
Praise will be your name
Walluken kinya doolking junguin eomin
Yours this earth will be
Walluken bookin nugaroungin gnunda
Your will will be done
Gnoola marka nungworroungunutch derilla
Like you do above the skies
Woocarndin geela gnowik gnowik wallukkanduk bannim
Give us this day our food
Winnuk coonguk kinya yathung giawonduk
Don't take any notice of evil doings
Gnoolanda winnacoongun marcoongetch marco gooleketch yathung giawook
Like we forgive other people their evil doings
Wambung goondin dindaworruk yathungie juk
Don't lead us into evil deeds
Joolun gurragnundin yathungie janyung
Lead us back from evil deeds
Wallukkaen kinya mikmeye jar eoma
Yours very powerful and brightness
Wallukkaen yere wongaren bar millakin
Always very no end
Doortakootthawill yere wamba jertook
For ever very without end.

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Art. XXXV.—*A Contribution to the Physiography of the Yarra River and Dandenong Creek Basins, Victoria.*

By J. T. JUTSON

(Victorian Government Research Scholar, University of Melbourne).

(With Plates LXXXVI.-XC.)

[Read 8th December, 1910.]

Introduction.

In this paper an attempt is made to throw some light upon the history of the Yarra River and Dandenong Creek Basins since the last great uplift of the land. The more recent minor changes of the Yarra near its mouth have been described by several writers, and upon these aspects I do not propose to touch. This paper is concerned mainly with the Yarra Valley upstream from Heidelberg, and with the basin of the Dandenong Creek generally. As will be noticed in the sequel, the two basins are in places intimately associated with one another, and thus they may be conveniently dealt with together.

Previous Literature.

Apart from Professor Gregory's work, which will be presently referred to, little has been published on the Yarra and Dandenong Creek Basins. Such literature as exists, and which bears on the subjects in hand, will be mentioned when dealing with the origin of the various land forms.

In 1903 Professor Gregory published his suggestive and stimulating work on the Geography of Victoria (1). In passing I would like to express my deep indebtedness to this book, and to point out that it is practically the pioneer work in Victoria in the application of the principles of modern physiography, of which at the present time Prof. W. M. Davis of America is perhaps the most distinguished exponent.

In this work Professor Gregory (pp. 106-113) discusses the history of the Yarra Basin, and suggests that most of the principal northern tributaries of the Yarra were originally continuous with the principal streams now flowing northerly to the Goulburn River, but formerly having a southerly flow; and also that a stream formed by the junction of some of these older larger streams (the Acheron-Watts and the Yea-Steel's Creek) originally passed over a gap at Beenak, and entered Western Port Bay through the Kooweerup Swamp. This of course was when the general surface of the Yarra Basin was at a greater elevation than it is at present. Subsequently the Yarra and Goulburn Rivers worked their way eastward and captured the various streams, dividing them into two portions in some places, and into three in the case of the river which he thought formerly passed over the Beenak Gap, and of course reversing the flow of some of the captured parts. The Yarra, he states, cut its way along an eastern and western valley, guided by the earth movements that succeeded the eruptions of Dandenong and the Black Spur. These eruptions Professor Gregory elsewhere (2, pp. 212 and 214) states, were probably post-Palaeozoic, and certainly earlier than the Upper Cainozoic, and might belong to any part of the Mesozoic or Lower Cainozoic.

The present paper does not discuss the questions here raised by Prof. Gregory, but confines itself mainly to the history of the Yarra and Dandenong Creek since the last great uplift of the land, which, in the writer's opinion, occurred after the formation of the peneplain, which is subsequently referred to as the Nillumbik Peneplain.

Prof. Gregory (1, p. 84) also refers to the Yarra Plateau as the third southern spur of the peneplain running southward from the Primitive Mountain Chain. This peneplain, he states, ran from the Strathbogie Ranges across the present main divide between Mt. Disappointment and Mt. Arnold, forming the old platform under the Dandenongs. He further remarks (p. 85) that most of the Yarra Plateau may be regarded as a shelf on the eastern border of the Melbourne Basin, of which the eastern boundary may then be drawn along the ridge through Queenstown, Christmas Hills and Mooroolbark.

East of this line is the basin of the Middle Yarra, Kooweerup Swamp and Western Port, which were probably once part of a connected basin.

In the same work (pp. 106-107) Prof. Gregory points out that the Yarra does not cross from its middle basin to its lower basin by what appears to be the natural course—viz., through the gap at Mooroolbark used by the railway, but after meandering through the Yarra Flats the river suddenly turns off into the hilly country known as the Christmas Hills. It flows in a deep gorge through them till it reaches the plains again near its junction with the Plenty River. Its course he maintains is therefore clearly antecedent to the present topography of the country; but its narrow gorge and rocky cataract broken course show that it has here the characters of a young as well as an antecedent river, and is, in fact, a revived river.

The possible peneplain of which the tops of Mt. Macedon and the Dandenong Ranges are the remnants, as suggested by Prof. Skeats (3, p. 188), will not be discussed in this paper.

General Description.

The principal physical features of the areas in question are fairly well known, so that a brief description will be sufficient for the purposes of this paper.

Treating the Yarra first, this river rises near Mt. Baw Baw, and thence passes westward, developing into a fairly open, matured valley, with well-developed tributaries, until it reaches Warburton. Here, as noted by Mr. F. G. A. Barnard (4, p. 245), it is confined to a deep and somewhat narrow gorge, after passing which its valley gradually widens until it turns to the north near Killara, and meanders through broad alluvial flats as far as Healesville, where it swings away again to the westward through similar flats as far as Yarra Glen. It then turns to the south-west, still bordered by flats, but now principally on the left bank only. The right bank rises steeply to a considerable height above the river, and these features are maintained, with the exception noticed below, until Brushy Creek (a southern tributary) is met.

Here the river plunges into a deep narrow gorge; and the stream passes from the slow meanderings indicative of old age to the swift-flowing, rocky-bedded river characteristic of youth. This gorge continues as far as Templestowe, from where the country becomes more open and the river more staid, until at Heidelberg it has a wide-bottomed valley, and the river meanders through its flood-plain.

At Fairfield the river again becomes youthful in appearance, due to the partial infilling of the old valley by basalt. It maintains its narrow valley for some distance; but the valley gradually widens as it approaches Melbourne, becoming once again the mature or old river, which feature it retains until it meets the sea at Hobson's Bay.

The character of the valley at Heidelberg has been described by Dr. T. S. Hall (5, p. 42) and the writer (6, pp. 165 and 166).

The tributaries of the Yarra do not present many diversified forms. Those entering the stream on its right bank comprise streams running mainly through silurian country, such as the Plenty, the Diamond Creek, Watson's Creek, Steel's Creek and others near Yarra Glen. They also include the Watts River, the Badger Creek, the Don and the Dee Rivers, and the small streams near Warburton, all of which belong to dacite country. Farther east there are the O'Shannassy and other rivers, which are silurian.

These tributaries are, with the exception of the small streams at Warburton, deeply trenched, and have, generally speaking, rather narrow valleys. They enter the Yarra with accordant junctions, are well graded, and their development has clearly been determined by the stage of growth of the Yarra itself. In other words, they are normal tributaries.

The tributaries at Warburton are very short, with steep grades and very narrow valleys. Their waters are very swift-flowing, and they, with similar streams on the opposite bank at the same locality, constitute a group of mountain torrents. Their rocks are dacite on the northern, and mainly grano-diorite on the southern side.

The affluents entering the Yarra on the left bank are, as a rule, considerably shorter than those entering on the right bank. They comprise Gardiner's and the Koonung Koonung

Creeks, whose valleys are broad open ones, due to the comparatively slight elevation of the country above sea-level, and the mature state of the Yarra where these streams junction. Farther east, the Mullum-Mullum, Anderson's, and Narrmeian Creeks possess narrow, deep valleys, consistent with the Yarra itself at their various points of entrance. The five tributaries just mentioned all have accordant junctions, and are all essentially silurian streams.

The next valley to the east, that of the Brushy Creek, offers a striking contrast to its immediate neighbours, the Narrmeian, Anderson's and Mullum Mullum Creeks. The Brushy Creek valley is a broad, open, flat-bottomed one, with a sluggish stream meandering through its own alluvium, while further east the streams running in a northerly direction towards the Yarra, such as the Olinda Creek and other small watercourses in the parish of Yering, do not reach the Yarra, but lose themselves in the broad, marshy flats bordering the Upper Yarra. The valleys of these streams before entering the flats are bounded by low hills with gently sloping sides.

Beyond the flats again to the east, another nest of closely related streams occurs, including the Woori Yallock Creek, Hoddle's Creek, and the Little Yarra. These are fairly well developed, chiefly in silurian country, and possess the normal characteristics already noted of other similar streams.

At Warburton, as above remarked, mountain torrents exist on both sides of the river.

Farther to the east again, the southern tributaries appear to be generally similar to those entering from the northern side, and are chiefly in silurian country.

The basin of the Dandenong Creek offers in several respects a marked contrast to that of the Yarra. The latter is much larger than the former, which is generally at a low elevation, and is fed by ground of little height, with the exception of some drainage from the Dandenong Mountains. The result is that the main stream—the Dandenong Creek—is very small, and its tributaries, with the exception of the Blind and Corhanwarrabul Creeks, are quite insignificant. A further result is that the valleys are generally wide, shallow and tending to flat bottoms, with alluvial flats. These characteristics are

especially noticable towards the mouth of the Dandenong Creek (where they would be expected), and, where unlooked for, at the head waters of the stream, and its principal tributaries.

The main geological formations may be seen from the map, showing the Yarra and portion of the Goulburn Basins. The main divisions are the silurian sedimentary rocks, the dacite and granodiorite, and the tertiary sands and gravels. The silurian occupies most of the peneplain through which the Yarra runs, as well as forming part of the divides. The granodiorite and dacite form the highest lands of the area, rising to about 4000 feet at Mount Donnabuang, near Warburton. They are found about the divides.

The tertiary sands and gravels forming the coastal plain to the east and south-east of Melbourne, are a thin cap on the silurian rocks, and occur in the southern part of the country now dealt with. They have in places been much deunded.

The Yarra Plateau.

Prof. Gregory's description of the Yarra Plateau has already been quoted. It is proposed to extend the boundaries of this plateau, so as to include country that naturally falls within its area, as well as the coastal plain to the east and south-east of Melbourne. The latter is included for convenience of reference.

The plateau is bounded on the north by the Main Divide, or by some of the spurs of the latter; and Mount Disappointment may be regarded as the western extremity of its northern boundary.

The rise from the plateau at its northern boundary is sharp. This is noticeable at Mount Disappointment, and particularly so at Bear's Sugar Loaf, a high, southerly-projecting spur from the Divide. This spur at its southern end is sharply and steeply truncated, which may be due to denudation during the formation of the peneplain, of which the Yarra Plateau forms a part.

In contrast are the spurs from the Main Divide about Yarra Glen and Healesville. They are long and sloping, and continue

so down into the valley of the Yarra. These spurs indicate that this part of the country has escaped the planation which formed the peneplain, and that such country apparently belongs to an earlier cycle of erosion than the plateau.

Belonging also apparently to this earlier cycle of erosion is the Yarra valley, east of Warburton. This area and the country mentioned in the last paragraph, have not been sufficiently examined to state whether any evidence exists in support of this earlier cycle, such as old valleys trenched by younger ones.

From the Main Divide to the Yarra, the plateau is bounded on the east by the higher country at Steel's Creek and farther east. The boundary then follows the Yarra to Brushy Creek, thence along the western side of the latter to Burt's Hill, thence south-westerly through the Springvale district to the sea. Its western boundary may be regarded as a line drawn from Mount Disappointment southward to Port Phillip Bay.

Another part of the plateau is probably most of the Woori Yallock and Hoddle's Creeks Basins. This part is separated from the main area by the depression of the middle Yarra country. Its exact relations with the main part of the plateau have not yet been determined.

The Croydon Senkungsfeld.

The Yarra Plateau is flanked in parts by a belt of low country, characterised by wide alluvial flats, low ridges and broad, open valleys, of which those at Yarra Glen and Bayswater may be taken as types. The tops of the ridges indicate that this low belt of country had originally a level surface, and is really a dissected plain.

The difference of elevation between the Yarra Plateau and this lower country I regard as due to unequal uplift, the less raised portion being a true Senkungsfeld, which can conveniently be referred to as the Croydon Senkungsfeld. Croydon is situated on the boundary between the Yarra and Dandenong Creek Basins, and as the Senkungsfeld belongs to both, the name of this township has been adopted for this depressed belt of country.

The Senkungsfeld is bounded on the west by a line running north-easterly from about Springvale to the Dandenong Creek (just west of the Bayswater railway station). Crossing the creek it continues in the same direction as far as Burt's Hill. It then runs a little to the west of north to the Yarra at the mouth of the Brushy Creek, then north-easterly to Yarra Glen. From here the boundaries have not been definitely traced, but probably it trends eastward (a little to the north of the Yarra) to Healesville, thence southward close to the great dacite masses of Mounts Riddell and Toole-be-wong to the east of Killara, thence across the valley of the Yarra at the latter place to the Warramate Hills, thence northward along their eastern edge, thence westward to Lilydale, and southerly along the western edge of the Dandenong Ranges and adjacent hills to Dandenong.

Thus this depressed area consists of a long north and south valley running through Croydon to Dandenong, the low country about Yarra Glen, and the narrow valley between Mount Toole-be-wong and the Warramate Hills. Mr. Thiele in his suggestive and interesting little paper (7, p. 103) has noted the depression of the Dandenong Creek area; but suggested no reason for its existence.

The depth of the original surface of the Croydon Senkungsfeld below the general level of the Yarra Plateau is at Croydon about 140 feet (by aneroid), and at the gorges subsequently described as the Yering and Warrandyte Gorges, about 200 feet by the same instrument. At the "Kopje" it is only about 85 feet. Elsewhere the heights have not been determined.

The Lilydale basalt, although higher than most of the depressed area, cannot be separated from the latter. Its greater height is due, in the writer's opinion, to its greater resistance to erosion than the softer neighbouring rocks. The relations of the higher country chiefly occupied by the pyroclastic rocks of Evelyn and surrounding country (which are regarded as related to the dacites), to the Senkungsfeld and the Yarra Plateau, have not yet been determined.

So far as its boundaries have been definitely traced, the Senkungsfeld is mainly due to faulting; it is therefore a fault-block.

For reasons that will be subsequently stated, the Senkungsfeld is regarded as only relatively and not absolutely depressed. The whole country was uplifted, but certain portions received greater elevation than others.

In stating the boundaries of the Croydon Senkungsfeld, no reference was made to its possible extension south of Dandenong, as my personal observations in connection with this paper have not extended beyond this point.

From the known contour of the country, however, to the south of Dandenong, and from the geological map accompanying Selwyn's report of 1856 (8), the Senkungsfeld appears to clearly extend in the same direction (south-westerly) through the Carrum Swamp and possibly under Port Phillip. This question is dealt with more fully under the section describing the faults and fault-scarps.

The Nillumbik Peneplain.

This comprises the Yarra Plateau and the Croydon Senkungsfeld, parts of the same form, but at different levels. Sufficient observations have not yet been made to adequately discuss the cause of the movements which have brought about these different levels.

Prof. Gregory regards the Yarra Plateau (as defined by him) as a peneplain. That it is so, and also in its widened definition, may be seen on looking from any elevated point commanding a comprehensive view of the country. One of the best of such view-points is Garden Hill, at Kangaroo Ground.

Within the boundaries of this peneplain is included the coastal plain stretching eastward and south-eastward from Melbourne. This coastal plain consists of marine and fresh water tertiary sands and gravels, laid down upon the denuded, even surface of the silurian rocks whilst the more inland country was being reduced to a peneplain continuous with that on which the sands and gravels were deposited. Thus the true peneplain to the north merges into the coastal plain, and there are thus two physiographic forms, but for convenience both are grouped together as the Nillumbik Peneplain.

This peneplain rises gradually to the north and east from sea-level to varying heights, in its central portions being from 400 feet to 700 feet in elevation, according to its position in the area.

The peneplain as here defined is apparently that referred to by Prof. Skeats (3, p. 189) as formed at a level of only a few hundred feet above sea level. He regards this peneplain as being formed through the softer sediments being easily base levelled, and the more resistant dacites preserving remnants of an older peneplain, to which he also refers.

The Nillumbik Peneplain seems to die out to the east about the Steel's Creek country, and pass into that of an earlier cycle of erosion, to which, as previously noted under the description of the Yarra Plateau, the valley of the Yarra east of Warburton also belongs. Until more observations are made, however, the possibility of faulting along some of the boundaries of the Nillumbik Peneplain and the higher lands (for example at Bear's Sugar Loaf) cannot be altogether excluded. This, however, would not affect the character of the Nillumbik Peneplain, which is a true river-made plain, but would affect the amount of vertical denudation between the present Nillumbik Peneplain and the high land by which it is bounded.

The Faults and Fault-Scarps.

Two strongly-marked faults have been definitely traced.

The first—named the Brushy Creek Fault—forms part of the western boundary of the Croydon Senkungsfeld. It commences at about the Dandenong Creek to the west of Bayswater railway station, and runs north-eastward to the west of Croydon railway station as far as Burt's Hill; thence a little to the west of north, forming the western side of the Brushy Creek valley, to the Yarra River at the mouth of the former stream. This fault is about eight miles in length, and forms a prominent scarp in the landscape. It is worthy of observation that it follows the strike of the silurian rocks, which here on the west are in part somewhat quartzitic sandstones. The nature of the silurian rocks immediately to the east has not yet been determined, but possibly the earth found relief

between a fairly hard and a softer band, following the strike of the rocks. It may here be stated that the difference in hardness between the rock-bands mentioned is quite insufficient to account for the existing topography.

South of the Dandenong Creek, the Brushy Creek Fault cannot be traced. If, however, a line be drawn south-westerly in continuation of the fault to about Springvale, it will be seen that while the general level of the country along this line gradually descends to the south, it also appears to steadily drop to the east, until the low ridges and flats of Bayswater and Scoresby are met with. Thus the fault seems to die out and become replaced by a gentle tilting approaching a slight fold. This idea is supported by the decreasing throw of the fault when traversed from north to south.

The second fault, which may be referred to as the Yarra Fault, runs north-easterly from the northern end of the Brushy Creek Fault to about two miles to the north of the Yarra at Yarra Glen. It constitutes a boundary of the Croydon Senkungsfeld. Its length is about nine miles, and it keeps close to and is practically parallel to the Yarra River. It is on the right side of the stream, except as will be noted later.

This fault also has a very prominent and practically unbroken scarp.

The difference in height at various points (e.g., at the mouth of Brushy Creek, about 200 feet, at Croydon abut 140 feet, and at the "Kopje" about 85 feet), between the Yarra Plateau and the Croydon Senkungsfeld, indicates approximately the throw of the Brushy Creek Fault, whilst similarly the throw (about 200 feet) of the Yarra Fault is indicated at the Yering Gorge.

The nature of the other boundaries of the Croydon Senkungsfeld have not yet been ascertained, but from casual examination there appears to be a strongly marked but broken scarp running from north of Yarra Glen (a little above the junction of Steel's and Dixon's Creeks), eastward towards Healesville. This scarp is probably due to a fault. Faults on each side of the Yarra north of Killara, one along the edge of Mt. Toole-be-wong, and the other on the eastern side of the Warramate Hills, probably account for the depression here.

Definite conclusions on these points must await further examination.

A careful examination of the country along the western edge of the Dandenong Ranges has not been made; so that the nature of the junction here between the Croydon Senkungsfeld and the mountains has not been determined by personal observation.

I have however come to the conclusion that it is extremely probable that such junction is a fault, and that from the following considerations:—

If the eastern boundary of the Croydon Senkungsfeld along the western edge of the Dandenong Ranges be continued in the same (south-westerly) direction, it will be found to pass along the western edge of the granodiorite at Dandenong, along the eastern side of the Carrum Swamp, and along the eastern side of Port Phillip Bay to the Nepean Peninsula. This line it will be noticed, is on the western edges of the granodiorite of Mts. Eliza and Martha and Arthur's Seat, which are so sharply defined along the coast.

Selwyn in 1857 (9, p. 33) stated that a fault extended in a direct line from Frankston to Arthur's Seat, parallel to the coast. This line is included in the line above noted, stretching from the Dandenong Ranges to the Nepean Peninsula.

As already stated, the Brushy Creek Fault appears to pass southward into a gentle tilting or folding, which enables the western boundary of the Croydon Senkungsfeld to be traced (in continuation of the Brushy Creek Fault) towards about Springvale. If from the latter place the line be continued in the same direction, it will be found to pass through Mordialloc, which is at the western end of the Carrum Swamp.

There is no reason to doubt that Selwyn's fault line is a true fault. It bounds, as Mr. Hart has pointed out (10, p. 257), the granitic areas of the district; its continuation to the north-east bounds the depression of the Carrum Swamp, and also the igneous rocks of the Dandenong Ranges. West of the latter a Senkungsfeld exists. There seems little doubt therefore that a strongly marked and remarkably straight fault exists from the northern end of the Dandenongs to Dromana, a distance of nearly 50 miles. This fault may appropriately be

termed the Dandenong Fault. Whether this fault crosses the Nepean Peninsula cannot at present be stated.

A continuation south-westerly from Dandenong of the Croydon Senkungsfeld would account for the depression of the Carrum Swamp, and perhaps for the indentation of Port Phillip from Mordialloc nearly to Sorrento. It also indicates a valley extending from the Yarra at Brushy Creek mouth through Croydon, Dandenong, the Carrum Swamp and, possibly, under the waters of Port Phillip Bay, and dating from the time of the uplift of the Nillumbik Peneplain. As will be subsequently shown, the Yarra does not appear to have ever occupied this valley.

The Dandenong Fault may be a line along which repeated movement may have taken place; but we are here only concerned as to its effect in the formation of the Croydon Senkungsfeld.

Dr. Hall (11, p. 204) apparently holds that the part of the Dandenong Fault indicated by Selwyn was formed during the drowning of the lower parts of the Yarra and other streams, and the formation of Port Phillip Bay. The fault however appears to date back at least to the uplift of the Nillumbik Peneplain, the time of which is subsequently discussed, and which was long prior to the formation of Port Phillip.

The Dandenong Fault and the boundaries of the Croydon Senkungsfeld around the great mass of acid igneous rocks forming the Dandenong Ranges and adjacent hills, suggest that these igneous masses and those of Mounts Eliza and Martha and Arthur's Seat are horsts.

Mr. Griffith Taylor (12) and Mr. C. A. Süssmilch (13) have explained some of the New South Wales topography by faults and Senkungsfelder. The writer's conclusions as to the origin of the topography dealt with in this paper were arrived at before perusing these interesting papers.

The Yering Gorge.

It has been stated above that the Yarra Fault mainly keeps to the right bank of the Yarra River. An exception occurs about two and a-half miles (in a direct line) to the east of the

mouth of the Brushy Creek in the form of a deep, narrow and isolated gorge of the river about a mile in length. Its entrance and its exit are bounded by broad flats.

This gorge throws a flood of light upon the history of the topography of the country, and I have therefore given it a distinct name—the Yering Gorge. Its significance will be subsequently discussed.

The Mitcham Axis.

The southern boundary of part of the Yarra Basin may be regarded as a line running from the north of Camberwell to Burt's Hill. This is not strictly correct, as this line has been shown by Mr. Thiele (7, p. 103) to have been breached by the Mullum Mullum Creek. Gardiner's Creek is also an anomaly. The effect of the latter has probably been to divert the waters of Main Creek and adjacent streams to the Yarra instead of directly to the sea. This will be subsequently discussed. For the purposes of the argument the dividing line, as stated above, may be accepted.

This line keeps fairly close to the Lilydale railway line from Camberwell to Mitcham, and then runs more to the north in a north-easterly direction.

Between Croydon and Lilydale the water-parting between the Yarra and the Dandenong Creek Basins is more irregular, and it loses something of the ridge-like character indicative of the western portion. The low ridges however about Croydon and Mooroolbark appear to have northerly and southerly slopes as if the dividing line were originally continued between these places. All the drainage to the north and east of Lilydale enters the Yarra.

The country along the line between Camberwell and Burt's Hill gradually rises. About a mile north of the Canterbury railway station it is 380 feet, at the Surrey Hills reservoir it is 420 feet, and at Mitcham over 500 feet above sea level. At Burt's Hill—i.e., on the Yarra Plateau, at the base of this hill—it is by aneroid determination about 560 feet above sea level. It is convenient to refer to this line as the Mitcham Axis.

This axis may be a true crustal deformation formed during the differential uplift of the Nillumbik Peneplain. Whether it is so or not as regards the northern and southern slopes, there seems to be no doubt that its gradually increasing elevation eastward is due to earth movement. At Burt's Hill the rocks snapped, forming the Brushy Creek Fault.

The axis, if wholly due to crustal movements, really forms an elongated dome, truncated at its eastern side.

The general uplift of a wide area of country had given a southerly slope to the Yarra Plateau from the foot of the Main Divide, and this slope met the northern slope from the Mitcham Axis somewhere about the course of the present Yarra (west of Brushy Creek). The axis therefore determined to some extent at any rate the course of the Yarra, and fixed the boundary line between the basin of that river and that of the Dandenong Creek.

At Mitcham and eastward to Burt's Hill at Croydon, the northern and southern slopes can be clearly seen from the axis. Farther west however the slopes are less in grade, and therefore not so distinct. About Box Hill the axis is a broad level stretch of country, in which streams have in their head waters incised themselves in a westerly direction. These streams, however, in their lower courses flow, as a rule, to the north or the south.

The evidence as to the warping of the country along the Mitcham Axis is not based on the structure of the underlying rocks. No definite results can be obtained from them. It is based on the slopes of the ridges to the north and south of the axis, particularly at Mitcham and Burt's Hill, on the gradual rise of the axis from west to east, and on the slope of the country west of Bayswater being towards the east, whilst some of the streams run westerly, as will be subsequently noted.

The amount of fall along the ridges has not been determined; but those extending from the Mitcham Axis northward to the Yarra appear to have a gentle slope until the Yarra is approached, when they dip sharply towards the river, the sharp dip being clearly due to denudation. It is difficult however to see how denudation since uplift could have produced the main

slopes of the ridges. Moreover, the actual position of the axis appears to be that of an original water-parting. Were this due to denudation since the last great uplift, we should expect much more irregularity in its outline than at present exists.

In addition, differential uplift is indicated by the formation of the Croydon Senkungsfeld.

It is possible however that the slopes to the north and south of the Mitcham Axis may have been formed prior to the last great uplift, and not disturbed by that movement. This aspect will be dealt with under the section describing the monadnocks of "Pinemont," Croydon Hill and Burt's Hill.

The Slow Uplift of the Nillumbik Peneplain and the Former Character of the Yarra River.

The last great uplift of the land that took place was the elevation of the Nillumbik Peneplain. We have seen from the evidence of the Mitcham Axis and the Brushy Creek and Yarra Faults and their scarps, that such uplift was differential. The Yering Gorge furnishes us with evidence that the uplift was also extremely slow and gradual.

The river here pierces the scarp and hence the gorge. At its entrance and its exit, the gorge is bounded (on the left side of the river) by an alluvial flat. Between the two flats, the scarp descends on to a long, low ridge which steadily rises in a south-easterly direction. The scarp of the Yarra Fault is here about 200 feet above the low ridge at its base, and this low ridge is about 70 feet above the river. Taking a section in a south-easterly direction, there is first the Yarra Plateau, then the deep, narrow Yering Gorge, then the fault scarp descending to a low ridge, and then the latter rising gently towards the south-east. The plan and section of this part of the country accompanying this paper illustrate the matter.

It is clear that the river could not have formed the gorge while the country possessed any resemblance to its present contour. It is equally clear that if the Yarra Fault Scarp had been rapidly formed, the river could not have cut the gorge, but must have taken the then lowest part of the country—viz.,

that at the foot of the scarp on the low ridge above mentioned. The only feasible explanation is that the Yarra here is an antecedent river, that its course, when the Nillumbik Peneplain possessed a generally even surface at its base-level of erosion, was the same as that now occupied by and near the Yering Gorge, and that the uplift of the peneplain and the formation of the faults were simultaneous; and yet so slow that in spite of the differential movement the river held its course, and cut through the higher country as fast as the latter was uplifted.

Hence the formation of the Yering Gorge as an entrenched meander and the revival of the river. Apart from the gorge, the river occupied the Yarra Senkungsfeld, and so maintained in the depressed area the features of an old river.

The conformation of the country at the mouth of Brushy Creek also supports this view. It is at this point that the scarps of the Brushy Creek and Yarra Faults meet. The Yarra Fault Scarp here descends steeply, as at the Yering Gorge, to a low ridge. This ridge forms the right side of the Brushy Creek valley, and it is comparable to that described at the Yering Gorge. The top of the scarp is about 200 feet above the ridge, and the latter is about 50 feet above the river. The latter a little above its junction with Brushy Creek is bounded on the right side by the Yarra Fault Scarp, and on the left by an alluvial flat. Instead of cutting through the low ridge and thence running south along by the Brushy Creek Fault Scarp, it pierces the Yarra Fault Scarp and its valley becomes a deep gorge.

Unlike the Yering Gorge, this gorge continues through the Yarra Plateau to Templestowe.

As Warrandyte is the most central portion of this gorge, it is convenient to refer to it as the Warrandyte Gorge.

Although antecedent on entering this gorge, it appears doubtful whether the course of the Yarra through the Warrandyte Gorge as a whole is the same as that prior to uplift. Great bends are numerous, and, judged by the maps alone, suggest entrenched meanders. These would be expected on the slow uplift of a meandering stream. Close observation however along the whole length of the gorge shows that these bends

cannot be regarded as entrenched meanders; but are normal bends developed apparently entirely since the uplift. An attached map shows the present course of the river, and that initiated at the commencement of the uplift. The initial course is very straight, and meanders are conspicuous by their absence. Moreover, each bend is characterised by a long, gradually descending spur on the inner side of the curve showing that the bend was formed concurrently with the vertical erosion of the stream. Were the bends entrenched meanders, we should expect a curve carrying on its inner side, first a broad elevated patch around which the stream originally meandered, and then the long, sloping spur due to concurrent lateral and vertical erosion; but in every case the elevated patch is absent.

The bold bends of this gorge are explicable on the theory of slow uplift. The elevation was fast enough to allow continuous vertical erosion; but at the same time, slow enough to permit the river to curve extensively. Had the uplift been rapid, and could the river have adopted the same initial course as that already referred to in the portion now under discussion, then it seems fairly certain that the prominent bends so characteristic here would not have been developed. So far as observed, there is no evidence in the country drained by the Upper Yarra and the Dandenong Creek of any pauses or minor subsidences during the main uplift; but the purely lateral erosion at the extreme ends of some of the curves in the Warrandyte Gorge, as indicated by some alluvial flats, seems to indicate that the uplift has not continued right to the present time.

The exact position of the old course of the Yarra cannot be indicated. East of the Brushy Creek it did not apparently cross the line of the Yarra Fault Scarp (except at the Yering Gorge), otherwise further gorges would be in evidence. To the west of the Brushy Creek, its course is antecedent for a short distance, but beyond that it cannot be distinctly traced.

It is interesting to note how the Yarra River keeps close to the Yarra Fault Scarp. If the sag of the depressed area were greatest close to the scarp, as it appears without doubt to be, then whatever the original course of the stream in the depressed area may have been, as the slope towards the scarp

became more pronounced, the stream in the course of its meanderings would be forced nearer the scarp.

With the reservations mentioned, the observations now recorded confirm Prof. Gregory's view that the Yarra is an antecedent and a revived stream.

The broad depression running south through Croydon and Dandenong suggests at first sight that this may have been the old course of the Yarra, and that another stream (the present Yarra west of the Brushy Creek) worked its way eastward and captured the old river at the mouth of the Brushy Creek.

There appears, however, to be little doubt from the evidence of the Yering Gorge and the general contour of the country, that such depression is a true Senkungsfeld, and if this be admitted, the argument as to the Yarra having originally run through such depression falls to the ground, because such argument is naturally based on the assumption that such depression is river-made.

An interesting conjecture may be made as to what would have happened had the uplift of the Nillumbik Peneplain been rapid instead of gradual, and if at the same time such uplift had the same differential characters. The ridges forming the Senkungsfeld descend from Croydon and Lilydale to the north; and therefore a considerable lake would have been formed until drained through at the lowest point of the basin. The slow uplift however prevented the formation of a lake.

It may be pointed out that Prof. Gregory does not refer to the Yering Gorge. He remarks that the river turns off into the hilly country known as the Christmas Hills, and flows in a deep gorge through them to the plains near the Plenty River. This is evidently the Warrandyte Gorge. Had he observed the former gorge, it seems certain from its strong confirmation of his views that he would have cited it. It is however easily missed, unless the river be actuallv followed. Looked at from a distance—e.g., from near the Brushy Creek mouth—the river seems to flow uninterruptedly through low flats and ridges, bounded on its right side by the apparently unbroken Yarra Fault Scarp.

In passing, attention may be drawn to the fact that although comparatively little known, the Warrandyte Gorge

possesses some of the most beautiful scenery along the Yarra. It has a magnificent series of great bends (of which Pound Bend at Warrandyte is the largest and most impressive), as well as imposing cliffs, long quiet reaches and numerous rapids. Abundant vegetation also fringes the river.

It might be argued that the Croydon Senkungsfeld is due to direct subsidence, and not to differential uplift. This would imply uplift of the Nillumbik Peneplain as a whole, and then subsidence of the Senkungsfeld. This subsidence, if following closely on the uplift, must have been extremely slow—so slow in fact that the Yarra could erode the Yering Gorge, although the latter is in the higher country. Had subsidence been faster than the river erosion, the stream must have been deflected to the lower country, and the Yering Gorge would not be in existence. That the uplift was also slow is evidenced by the great bends of the Yarra in the Warrandyte Gorge.

Moreover, if subsidence occurred, it would not be expected that a series of ridges and valleys (although of little respective height and depth), such as are found in the Senkungsfeld, would be formed; but rather that an even floor on which alluvium would accumulate, would result.

Another view might be that the whole country was evenly uplifted, that the Yarra cut a young valley similar to the Warrandyte Gorge, throughout its length, and that a recent rapid subsidence is responsible for the Senkungsfeld. From this standpoint, the river-bottom (outside the Yering and Warrandyte Gorges) would be much below that of these gorges; a long, narrow winding lake would be formed, and the drainage would be altered. No evidence of the lake, or of its filling up, or of the diversion of the drainage, has been obtained, and so this view may be dismissed.

Taking the points mentioned into consideration, and also that direct subsidence means two distinct movements—the uplift of the peneplain as a whole and the subsequent depression of a part—for which there is no evidence; also that both movements would be very slow; and also that the one differential uplift meets all the facts of the case, there seems no reason to introduce a second movement, and, therefore, in this paper, the one movement—differential uplift—is adopted.

The Origin of the Yarra Flats.

These flats are part of the Croydon Senkungsfeld, and their explanation follows from the preceding discussion. Differential and slow uplift, resulting in the river cutting through the higher land as fast as the latter rises, means slow vertical, and consequently, strong lateral, erosion in the lower ground. Thus, wide shallow tributary valleys and extensive alluvial flats, through which the main river meanders and builds up a flood plain, are formed.

This has apparently happened in the area in question. During the excavation of the Yering George, the river cut as fast as the land rose. There has, therefore, been no time for lateral erosion, and the valley here remains a gorge. In the depressed area above the Yering Gorge, the stream was constantly reaching a temporary base-level, waiting for the erosion of the gorge. This gave great play to lateral stream erosion and atmospheric denudation, with the result that the low ridges have been cut into wide shallow valleys by the sluggish tributary streams, and the Yarra itself in its meandering course has formed the wide alluvial flats of Yarra Glen, Killara, etc.

The excavation of the Warrandyte Gorge has caused the same result. The distance however between the exit of the Yering Gorge and the entrance to the Warrandyte Gorge is short, so that the effects are on a smaller scale. The broad, flat-bottomed valley of the Brushy Creek owes its characteristic features to the same cause.

The Antecedent Character of the Dandenong Creek and Tributaries.

The general characters of the Dandenong Creek have been described above, and the slight tilting or dip to the east of the Yarra Plateau in the Dandenong Creek area was referred to.

The Dandenong Creek has generally a southerly direction, but instead of running south through the lowest part of the Croydon Senkungsfeld, which would appear to be its natural course, it passes into the higher country to the west, but works its way well into the Senkungsfeld again near Dandenong.

The main upper branch of the Dandenong Creek and the Blind and Corhanwarrabul Creeks have a westerly course, which is in opposition to the slope of the country. The upper parts of the Dandenong Creek are also characterised by the extensive flats at Bayswater, while lower down-stream, the valley contracts and possesses the normal characters of somewhat sluggish streams. The same remarks apply to some extent to the Blind Creek, and apparently also to the Corhanwarrabul Creek, but as the valley of the latter has not been fully examined, some reservation must be made with regard to this. This creek is not so important, as probably almost the whole of its lower course is within the boundaries of the Senkungsfeld.

It is difficult to understand how on a rapid uplift such courses could be formed; the only explanation appears to be that the streams are antecedent, and that the uplift being gradual, they were able to maintain their directions notwithstanding the opposing movement. As they have deepened their channels, they are also revived streams.

It will be noticed that no tributaries join the Dandenong Creek from the west, whilst those from the east are well developed. This is explicable, both from the present contour and from that prior to uplift. The Dandenong Ranges having a greater rainfall and a considerable area of high land, supply a fair volume of water to form watercourses, and hence the growth of the eastern tributaries. To the west of the Dandenong Creek, there is little ground not occupied by other drainage systems, and the country is at a low elevation. No tributaries of any consequence can therefore be expected from the western side.

The Origin of the Bayswater and Scoresby Flats.

The facts set forth as to the contour of the Dandenong Creek area furnish an explanation of these flats as well as show the antecedent character of the streams.

The flats referred to occur to the east of the Brushy Creek Fault Scarp, and towards the eastern end of the gentle tilt or dip farther south. As previously remarked, the Dande-

nong Creek and its tributaries kept their courses during differential uplift. That being so, the upper parts of the streams in the depressed ground would reach temporary base-levels, whilst the lower portions were still vertically eroding, and lateral erosion would therefore be active in the upper parts, tending to form wide alluvial flats and shallow open valleys. Down-stream the valleys would be more contracted, owing to vertical erosion being for the time the main occupation of the streams.

The origin of these flats may be explained in the following way.

Treating first of those flats near the head of the Dandenong Creek, which I have referred to as the Bayswater Flats, it is found that the creek here divides into several branches. The main stream runs westerly from the Dandenong Ranges. A branch runs southerly from Croydon, meeting the main stream at Bayswater. Two other small streams run south-westerly and north-westerly to the Dandenong Creek at Bayswater. Each of these small streams has formed rather extensive alluvial flats, but after they have joined together at Bayswater, the valley becomes narrower and the wide flats are absent. It is to the west of Bayswater that the higher land of the Yarra Plateau occurs, and therefore the explanation that the flats are due to slow and differential uplift seems the most feasible.

In the tributary running from Croydon, the flats are not so extensive as those more to the east. This may be explained (at least in part) in the following way:—The Croydon tributary is short, is in low ground, and has little drainage to work upon. Hence its denudation will not be very great. The main stream however of the Dandenong Creek rises in the high Dandenong Ranges, where there is an abundant rainfall, steep fall and fair area drained. The result is much greater formation of alluvial flats.

The change from the flats to the more normal type in the Dandenong Creek is not so marked as in the case of the Yarra. The transition is more gradual. This appears to be due to a more gradual change from plateau to Senkungsfeld in the Dandenong Creek area. A feature that appears to corroborate the explanation offered of the Bayswater Flats is the higher and steeper aspect of the right bank of the Dandenong Creek

as compared with the left. This is well seen where the creek to the west of Bayswater runs westerly and then southerly.

At Wheeler's Hill, a prominent point on the Fern Tree Gully Road, and on the western side of the Dandenong Creek, the ridges on the eastern side are so low compared with this hill that a fault scarp for a limited distance is here suggested again, rather than the gentle tilt or dip. This, however, is not clear. Wheeler's Hill appears to rise some distance above the general height of the Yarra Pleateau in this locality, and this may account for the apparent discrepancy.

The Blind Creek has some flats towards its head, and although apparently confirmative of the suggested origin of the Bayswater and Scoresby Flats, they are hardly distinct enough compared with the lower portion of the stream to warrant any definite conclusion being drawn. This indefiniteness may be due to the head waters of the creek not penetrating (according to the current maps) the Dandenong Ranges, and hence not gaining that supply of water and force required to form the flats.

The Corhanwarrabul Creek seems to be a similar case to that of the main upper portion of the Dandenong Creek, and the wide flats at Scoresby may probably be explained in the same way as the Bayswater flats. The Ferny and Monbulk Creeks (affluents of the Corhanwarrahal Creek) have cut back well into the mountains, which have furnished sufficient water and force to produce the flats. The Corhanwarrabul Creek valley has not been observed very much, so that stress cannot be laid on its apparent history.

Once differential movement is allowed during uplift, then, in addition to the more prominent features determined by such uplift, minor distinctions may arise, and it is possible that the Bayswater and Scoresby Flats are due in part to this cause. At the same time the explanation given above appears to meet the facts without any other hypotheses.

There is a depression beween Mitcham and Ringwood. This was formerly occupied by a branch of the Dandenong Creek, but as shown by Mr. Thiele (7, p. 103), its head waters have been captured by the Mullum Mullum Creek, and diverted to the Yarra.

The Age of the Nillumbik Peneplain.

Dr. Hall (14, p. 64) inclines to the opinion that the tertiary sands and gravels of Camberwell and adjacent districts are of fresh water origin, and of the same age as the marine beds at Beaumaris, that is, Kalimnan, and with this view the writer agrees.

These fresh water beds rest upon the surface of the Nillumbik Peneplain, and therefore would be deposited in the main after that portion of the peneplain on which they are deposited had been formed; it follows that the period of planation of the peneplain as a whole was during or prior to Kalimnan times.

The uplift of the peneplain probably dates therefore from late Kalimnan time or its close, and it has continued apparently to very recent times, with vibrations (to use a graphic term employed by Mr. E. C. Andrews) at the south-western end of the peneplain.

The Barwonian and Kalimnan series of rocks are generally regarded as of eocene and miocene age respectively. Recently the miocene age for the Jan Jukian, a subdivision of the Barwonian, has received support from an examination of certain groups of fossils by Mr. F. Chapman (15, p. 311).

The Kalimnan, which are admitted by all authorities to be younger than the Jan Jukian, will, if Mr. Chapman's views as to the age of the latter ultimately prevail, have to be removed to a later period, presumably the older pliocene.

I cannot express any opinion as to the ages of the rocks in question, from a palaeontological standpoint, but I would point out that from a physiographic point of view, the more recent age would be more acceptable; as, assuming that the Nillumbik Peneplain was completed during Kalimnan times and uplift then commenced, the erosion by the Yarra seems little advanced for a stream working from the close of the miocene time, especially when the erosion of the lower Yarra since newer basalt time is considered.

No definite statement however can be made on the point, and the fossil evidence will of course have ultimately to determine the question, but where the palaeontology is conflicting or interpreted by different authorities in different ways, then it

is well to bear in mind the possible service that physiography may render.

The Growth of the Yarra.

A glance at a map of the Yarra and its tributaries will show that the present main stream consists of various parts which have not always formed sections of the principal river of the area. From the nature and disposition of the rocks and the general configuration of the country, the growth of the Yarra would appear to be as outlined below.

As far up stream as Healesville, the Yarra is simple, and since the inception of the present topography—i.e., since the formation and uplift of the Nillumbik Peneplain—it has apparently been the main stream. At Healesville there is a sudden break. From a direction east and west, it changes to one north and south. The latter is not its natural continuation. The Watts River is really this. The present Yarra from Healesville to its junction with the Woori Yallock Creek, together with the latter, was no doubt at one time a tributary, but as it developed more rapidly than the Watts, the latter became the tributary and the former the principal river.

The reason of such greater development is obvious. The Watts River had the hard rocks of the dacite and granodiorite area to the north and north-east of Healesville to erode, and the Acheron, a strong affluent of the Goulburn, cutting back towards the Watts through soft silurian strata. The southern tributary of the Yarra had a wide and long area of similar silurian rocks to work upon. Hence erosion here was rapid, and the stream quickly cut its course backward and southward. The present Woori Yallock Creek was one of the upper arms of this stream, the other being the existing Yarra, east of the Woori Yallock junction to the Yarra Rivulet (or Little Yarra) and the latter itself. Most of this second arm is also in silurian country.

The present Yarra for some distance east of the Yarra Rivulet would be a weak tributary of this second arm, its weakness being due to the bar of hard igneous rocks at Warburton through which it would take long to cut.

Both the arms referred to ultimately reached in their head waters large areas of igneous rocks (with the exception of a narrow strip of silurian at the head of one of the branches of the Woori Yallock Creek, and which has apparently not favoured the latter, probably on account of a struggle with a south-flowing stream). These igneous rocks, from their great hardness, would act as a check upon the erosive activities of the Woori Yallock Creek and Yarra Rivulet. Meanwhile the Warburton tributary was steadily cutting its way between the dacite and granodiorite of that district. Behind (to the east of) these igneous rocks was a great area of silurian country, which if completely tapped, would greatly add to the volume of the stream. The igneous bar at Warburton is very narrow, compared with the width of the other areas of igneous rocks in the Yarra Basin. This gave the Warburton tributary an immense advantage over the other streams that were struggling for the predominant position. The bar was cut through, leaving the present narrow gorge at Warburton, and the river then rapidly eroded backwards. While the gorge was being eroded in the igneous rocks, lateral erosion was proceeding in the silurian area farther up-stream. This has continued, until, at the present time, there is the narrow gorge in the igneous rocks, with the short torrential mountain streams, whilst up-stream we have the more open valley with long, well-graded tributary streams.

The Warburton tributary therefore gained such an accession of strength that it rapidly became the present main stream, with its outpaced competitors subordinated to it.

The history here outlined probably commenced in the cycle of erosion prior to that originated since the uplift of the Nillumbik Peneplain.

Prof. Gregory has suggested that the Acheron and Watts Rivers were originally one stream passing through the Beenak Gap, and that the Acheron part was captured by the Goulburn, whilst the Watts and its southern continuation were captured by the Yarra. This question is outside the scope of the present paper, but it may be remarked that this could only have taken place when the whole country was at least as high as the Beenak Gap. This is probably what Prof. Gregory refers to

when he states that the south-flowing stream passed over the Beenak Gap probably at a time when the surface of the country was some 600 feet higher than at present (1, p. 113).

If Prof. Gregory's view be correct, the Yarra would not be the main stream until the capture of the various north and south streams mentioned by him. By the time however the Nillumbik Peneplain was formed, there could be no doubt that it was the principal river of the area. The conditions previously stated would therefore hold good in its future development; and I see no reason to doubt that such development was on the lines above suggested.

The Influence of Hard Rocks in the Evolution of the Topography.

The remarks made on the complexity of the Yarra illustrate this subject very well. A wider comparison is also available, and may now therefore be discussed. Such discussion, however, is almost entirely based on the map to be presently referred to, and not as the result of much personal observation.

It is proposed to compare the Yarra Basin with adjoining basins, and principally with that of the Upper Goulburn. The latest geological map of Victoria (a portion of which with some details omitted and an alteration of the boundaries of the basins near Mt. Baw Baw, is reproduced) shows, as of course is well known, that the Main Divide runs east and west, and the principal streams consequently to the north and south. Notable exceptions to this general rule are the Yarra and the upper portion of the Goulburn. These are east and west streams. It is also to be noticed that as the Main Divide approaches from the east Mounts Howitt and Buller, it becomes forked, the northern prong extending through Mount Buller, Tabletop, the Strathbogie Ranges, and thence to Trawool. The southern prong runs south from Mount Howitt to a little north of Mount Useful, and thence westward through Mounts Matlock, Arnold and St. Leonard to Mount Disappointment.

The southern prong is the actual Main Divide, and is along the northern boundary of the Yarra Basin. The Upper Goulburn has an opening at its western end connecting with the

country farther north, thus throwing that basin into that of the Murray. The term Upper Goulburn Basin is here restricted to that portion of the general basin, east of Trawool, bounded by the two prongs mentioned above.

The Yarra and Upper Goulburn Basins are largely bordered by old igneous rocks (dacites, granodiorites and porphyries), generally of much greater height than the surrounding country. These rocks are arranged roughly in three prominent parallel east and west bands, a feature which does not occur elsewhere in Victoria. These bands form respectively the northern boundary of the Upper Goulburn Basin, the boundary between the latter basin and that of the Yarra, and the southern boundary of the Yarra Basin.

It will I think be admitted that the present basins of the Yarra and Upper Goulburn and their divides are clearly determined by the outcrops of the igneous rocks mentioned, and that such basins have been blocked out by differential denudation, as suggested by Prof. Skeats (3, p. 189). Faulting may possibly have assisted; but denudation was probably the chief factor.

Assuming this to be correct, the size and form of the drainage areas become intelligible. The Yarra Basin is much smaller than that of the Upper Goulburn Basin, but this is not due to some mere chance. The hard rocks have determined the areas, subject to some favourable circumstance increasing one at the expense of the other.

Coming to greater detail, the Yarra Basin is bounded on the north by the granodiorite of Mt. Disappointment, by silurian rocks, and by the great mass of dacite and granodiorite forming Mts. St. Leonard, Arnold, Juliet, etc. The dacite of the Dandenong Ranges and the granodiorite stretching eastwards from these hills towards Baw Baw, form the southern boundary. The igneous rocks of the two boundaries mentioned are connected by the narrow bar of similar rocks at Warburton.

The effect of this bar has already been discussed when treating of the growth of the Yarra, and it seems reasonable to maintain that had no such bar existed the basin of the Yarra eastward would probably have been greater in area than

it is at present, especially in view of the short course of the Yarra to the sea. The bar however retarded denudation, and enabled the rivers of the adjoining basins to annex territory that otherwise would have been occupied by the Yarra.

In support of this proposition, attention may be drawn to the boundaries of the Upper Goulburn Basin, which, except in the east and south-east are igneous rocks. In the south-east corner, the basin abuts on to those of the Yarra and of the Thomson. The rocks here and for some distance north and south are ordovician and silurian sediments, and are practically homogeneous in character.

A struggle for supremacy (on even terms as regards the character of the rocks at their head waters) has taken place between the three basins mentioned; and, although the Yarra has the shortest course to the sea, yet its small drainage area and consequent less rapid erosion, together with the retardation due to the igneous bar at Warburton, have not enabled it to contest for territory successfully with the other basins. The battle has therefore been principally between the Upper Goulburn and the Thomson Basins.

On present knowledge the line of the original divide in the district of the head waters of the Goulburn and Thomson Rivers is unknown, but from the present divide's tortuous course, it may be safely asserted that it has been subjected to much shifting. It would appear, however, from the general direction of the divide, that it was, in the district mentioned, much further north than at present; and that by reason of the soft rocks and the greater drainage area, resulting in the rapid approach to base-level in its lower portion, and consequently greater power of erosion in its head water streams, the area of the Goulburn Basin has been increased at the expense no doubt of the Thomson and Yarra Basins. Whatever may have been the actual history, if a fairly wide band of dacite and granodiorite had stretched as a bar from Mt. Torbreck to Mount Buller, part or most of the south-east corner of the Upper Goulburn Basin may not have been included in such basin.

The fact that the Thomson and Tanjil Rivers, as shown by Messrs. Kitson and Baragwanath, Jun. (16, pp. 86 and 87), ap-

pear to have beheaded the upper portions of the Yarra does not invalidate the conclusions stated as to the cause of the limitation of the Yarra Basin, but suggests that this basin was at one time a little larger than at present, but for some possibly local reason it has been slightly reduced by capture.

Whether the Yarra will extend its territory at its head waters is difficult to answer. It has the great advantage of the shortest route to the sea, so that ultimately at any rate its upper waters should have a greater fall than those of the Thomson or the Goulburn. By this means it may possibly increase its boundaries.

As already noticed, the areas of the basins have been determined by the positions of the hard old acid igneous rocks; and the larger the basins, the greater the volume of water passing into the main river, and consequently the greater the vertical erosion of the main river and the headward erosion of its tributaries. The divides of the smaller basins are thus generally forced backwards, and such basins contracted, even in the areas of the igneous rocks. This is especially noticeable in the southern boundary of the Yarra Basin, and the northern boundary of the Upper Goulburn Basin. In the case of the former, the rivers of the great basin of Gippsland appear to have forced the divide to the north; whilst in the latter, the rivers of the Murray Basin—practically all tributaries of the Goulburn and Ovens Rivers—appear to have driven the divide almost to the southern edge of the igneous rocks.

A southward-shifting divide between the Upper Goulburn and Yarra Basins may explain (unless continued far to the north) the southerly slopes of the ridges north of the divide, which Prof. Gregory states there exist, and which slopes may not necessarily be evidence of old south-flowing streams from the north.

The Relations of Gardiner's and Main Creeks.

Gardiner's Creek is a tributary of the Yarra, and enters that stream south of Hawthorn after following a north-westerly course. Main Creek runs south-westerly from Black-

burn until it joins Gardiner's Creek near Murrumbeena. The two streams at their junction are at right angles to one another. When plotted on a map they do not appear perfectly normal to each other. A normal tributary generally joins the main stream at a more or less acute angle, and if Main Creek and the creek a little to the west are normal affluents, their courses would be expected to have a more westerly trend than their present directions. The question therefore arises whether some changes have not taken place during the development of the streams.

The general slope of the country south of the Mitcham Axis is towards the south-west. Main Creek follows this slope until it reaches Gardiner's Creek, which enters the Yarra at a normal angle. During its course, Gardiner's Creek cuts through the country between Malvern and Camberwell. According to the contour maps of the Lands Department, the country about half a mile to the north-east of the East Camberwell railway station is about 320 feet above sea level. It descends from here south-westerly to Malvern, whose highest point is about 212 feet above the same base. East of Malvern the country drops to 169 feet at Caulfield, 141 feet at Murrumbeena, and 187 feet at Oakleigh. The latter is the height of the railway station, but the country rises rapidly to the north-east and east. This high land also continues south-eastward towards Clayton township, from which a low ridge runs to the south.

The Caulfield and Murrumbeena country steadily drops in a south-westerly direction to the sea. It has been slightly eroded by small streams, but the latter have not affected the general level, which appears to be about that quoted for Caulfield and Murrumbeena.

Gardiner's Creek therefore passes from the lower country of Murrumbeena and Caulfield through the higher strip bounded on one side by Camberwell and on the other by Malvern. This, taken in conjunction with the direction of the Main Creek, suggests that the present stream disposition has not always been the same.

The following may have been the history of the streams. As the Yarra dug its course, a tributary was formed, which cut

its way backwards in a south-easterly direction. This is the present lower Gardiner's Creek. At the same time the Main Creek ran south-westerly across Murrumbeena, and thence down to the sea in a southerly or south-westerly direction, generally speaking. It was joined by the creek farther west, and, possibly, by a tributary running south-easterly, this tributary being now part of the present Gardiner's Creek.

The Yarra cut its channel quickly, and so gave a rapid fall for the short Gardiner's Creek. Main Creek had only a small drainage area; its erosion therefore would be much slower than the Yarra, and the fall would not be so great. Gardiner's Creek would tend therefore to rapidly cut backward, and possibly gradually annex the western stream, and ultimately Main Creek. The old stream south of Murrumbeena would thus be beheaded, and its upper waters diverted into the Yarra instead of into Port Phillip Bay direct. The lower valley of the old Main Creek would then be too wide for its drainage, and smaller valleys within the old valley would originate, some running towards the sea and others to the present Gardiner's Creek.

That some such series of changes has taken place is possible, but not certain.

The direction of the present Main Creek, and the creek to the west, the somewhat depressed country between Oakleigh and Malvern, and the direction of Gardiner's Creek across the slope of the country are explained by the suggestion made.

On the other hand, the denudation south of Gardiner's Creek has been so slight on account of the small drainage area and the low elevation of the ground that it is difficult to gather strong evidence of the changes. Another difficulty is Scotchman's Creek. This runs north-westerly into Main Creek, near the junction of the latter with Gardiner's Creek. It is possible that this was originally a short tributary of the old Main Creek. After capture of the heads of the latter by Gardiner's Creek, it offered a favourable channel for the backward erosion of the latter, and thus perhaps it has grown.

Another difficulty is the course of the Elsternwick Creek. This runs approximately parallel to Gardiner's Creek, and requires an explanation if the changes suggested have taken

place. Some favourable local circumstances may have brought this about.

Again, the elevation of the land in the Upper Yarra district was, as we have seen, very slow. This no doubt also applied to the land forming the area now under discussion, and if so, then Gardiner's Creek and its tributaries may be antecedent streams, but their directions do not appear normal under any circumstances.

We thus see that the question has at present to be left an open one. A more detailed examination of the country than the writer has been able to make might throw further light on the matter, and it is with this idea that the various possibilities have been here suggested.

Monadnocks.

Scattered about on the Nillumbik Peneplain are various hills rising above the general level of the peneplain. These represent the unplaned portions of the latter, and to them Prof. W. M. Davis has given the name monadnocks. The following have been recognised by the writer. There are other possible ones which I have not yet examined, and in addition there are no doubt further ones in country which I have not yet traversed. Some of the outlines of these forms are drawn on an accompanying plate.

Morang Hills.

These have been referred to in the writer's paper on the Plenty River (6, pp. 164 and 167). They were there suggested as a monadnock, and from further observations there appears to be no doubt that they form a true monadnock. Their preservation is due to the core of granite, and the indurated sedimentary rocks surrounding the granite.

Sugar Loaf Hill (Mont Park), near Heidelberg.

This is a small hill with its longer axis running north and south. It has a slightly greater elevation than the surrounding peneplain, and its projection is clearly due to the very

hard rocks of which it is composed. The surrounding rocks are soft silurian sediments. The geology of this hill presents some interesting features, and is being worked out by Mr. F. Chapman and myself.

"Pinemont," Croydon Hill and Burt's Hill.

"Pinemont" and Burt's Hill are on the line of the Mitcham Axis. This is rather a striking coincidence, but whether actually climbed, or viewed from a distance, as from near Kangaroo Ground, they appear to be undoubted monadnocks. Their occurrence on the Mitcham Axis suggests the possibility that this axis was perhaps in existence at the time of uplift of the Nillumbik Peneplain, due to being the old water-parting between the old Yarra and Dandenong Creek Basins. The antecedent character of these streams would permit of this conclusion being drawn, and as the water-parting is generally least denuded, monadnocks would naturally occur there.

In addition, even when reduced to a peneplain, gentle slopes on either side of the water-parting would exist, and might be preserved on uplift. If this be the true history of the case, then the suggested tilting to the north and south of the Mitcham Axis might not hold good. To some extent therefore this question must be left open.

Mr. Thiele (7, p. 103) has referred to "Pinemont" as a conspicuous conical hill rising to about 600 feet above sea level, and marking the position of the old water parting. This hill is a conspicuous landmark from many parts of the country. Perhaps the best view of it is from the Surrey Hills Reservoir, from which its residual character is clearly seen. It rises about 100 feet above the level of the peneplain at its base. It is difficult to account for the projection of "Pinemont" from the nature of its component rocks. These so far as visible are not appreciably different in their hardness from those of the surrounding country.

Croydon Hill occurs a little to the south of Burt's Hill. They both rise about 100 feet above the level of the Nillumbik Peneplain at their bases. The peneplain is here about 560 feet above sea-level. They are rather elongated conical hills. Their

exposed rocks are fine-grained, tough sandstones, with some quartz veins. With the sandstones are no doubt interbedded shaly rocks. The sandstones in places become almost quartzites, and in the narrow north and south belt, comprising Croydon and Burt's Hills and the "Kopje," the rocks seem somewhat more resistant than elsewhere. The greater difficulty in the removal of these hard rocks may therefore account for the monadnocks mentioned.

The "Kopje."

This is an isolated hill on the Nillumbik Peneplain, just west of the Brushy Creek Scarp, and close to the Canterbury-road. It is clearly a monadnock, and it sweeps up to a height of probably nearly 100 feet above the surrounding peneplain as a small but bold cone.

A most instructive section can be obtained here. Taking a traverse from the west of the "Kopje" we have first the Nillumbik Peneplain, then this monadnock, then the peneplain again for a short distance to the Brushy Creek Fault, where the Nillumbik Peneplain is thrown down about 85 feet. Farther east at a lower level again is the alluvial flat, through which a tributary of the Dandenong Creek meanders. Thus there are four distinct levels of country, the explanation of which may be inferred from the earlier part of this paper.

Kangaroo Ground.

This high ground is due to a small patch of basalt, which is generally regarded as older basalt. This and that capping the hills at Greensborough will be dealt with in another paper.

The basalt at Kangaroo Ground rises well above the general peneplain of the sedimentary silurian rocks (the Nillumbik Peneplain); such elevation appears to be due to the basalt having been erupted before the formation of the peneplain, and having largely resisted the general planation by reason of its superior hardness.

The Kangaroo Ground therefore forms a true monadnock, although somewhat dissected.

At the south-western end of the basalt, and just south of the main road, a sharp cone of silurian rocks rises some height above the peneplain. It is also higher than the basalt abutting, but the latter is somewhat denuded here. This hill is also a monadnock.

Lilydale Basalt and Quartzites.

These are apparently monadnocks on the Nillumbik Peneplain, which is here in the Croydon Senkungsfeld; but they have not been sufficiently examined to be adequately discussed.

Warramate Hills.

These occur about two miles to the nort-west of Killara railway station. They are marked on the parish map of Gruyere. The two chief hills are Briarty's Hill (an old Trig. station) and Steel's Hill.

At Killara the Wandin Yallock Creek enters the wide flats through which the Woori Yallock Creek and Yarra River wind towards Healesville. West of Killara the Wandin Yallock Creek is in a comparatively narrow valley, with well-defined sides. From the top of this valley the country is seen stretching away to the south-east, south and west as a fairly even, but dissected surface.[1] From this surface a ridge runs northward, steadily rising, and stretches out as an elevated tongue bounded on the north, east and west by much lower land. This ridge forms the Warramate Hills. At Briarty's Hill the ridge rises rather abruptly, the height of this hill being according to an aneroid reading about 1400 feet above sea-level, and about 1100 feet above the alluvial flats at Killara. A little to the north of Briarty's Hill is Steel's Hill, which does not appear to be so high, and from Steel's Hill there is apparently an abrupt descent. The Warramate Hills form a prominent feature in the landscape from various points of view.

The exposed rocks of Briarty's Hill are moderately tough sandstones, with abundant quartz in parts. There seems no reason why they should specially resist denudation, so as to

1 Whether this surface is part of the Nillumbik Peneplain, or not, I cannot say, as its relations have not been determined.

project to the height that they do above the plateau country to the south.

I can, however, at present assign no other cause to the prominence of the Warramate Hills, which may therefore tentatively be regarded as a gigantic (in comparison with others in the Yarra Basin) monadnock.

Subsequent research may determine that these hills are due to strong faulting of the adjacent country in times prior to the formation of the Nillumbik Peneplain; or they may for some unknown reason be the residuals of one or more peneplains.

More measurements and wider observations are necessary before coming to any conclusions as to the existence of peneplains above the Nillumbik Peneplain, and below that suggested by Prof. Skeats as on the tops of the dacite masses referred to by him; but it may be pointed out that the Morang Hills, "Pinemont," Burt's and Croydon Hills, and the "Kopje" appear to be at about the same height (somewhere about 100 feet) above the Nillumbik Peneplain. This strongly suggests that another peneplain existed at this level. The height of the Divide just to the east of Mt. Disappointment is about 1700 feet. The Warramate Hills are about 1400 feet. Connecting these two points, a third possible peneplain below the tops of the dacite rocks suggests itself.

View-Points.

A few remarks on these may not be out of place. All the monadnocks mentioned, as would be expected, constitute excellent points for observation of the surrounding country. Close to Melbourne, Sugar Loaf Hill offers a very fine panoramic view.

At Kangaroo Ground, in the basalt country, Garden Hill occurs. This is on the main road to Christmas Hills, a little east of where the latter road diverges from the Queenstown road. This hill and the adjacent basalt are almost destitute of trees, and as the basalt is well above the surrounding country, an excellent view of the latter is obtained. There is no interruption in any direction for many miles. It is from here that the general character of the Yarra Plateau is well seen.

Another fine view-point is Bear's Sugar Loaf, north of Arthur's Creek township. From the latter place, it has the appearance of a gigantic pyramid, due to its ridge-like character and sharp truncation at its southern side. Perhaps from this hill the finest view is obtained of the actual Main Divide. The configuration of the latter, with its numerous branching gullies seaming its sides, is very distinct.

The higher view-points, such as Mount Dandenong, Malleson's Lookout, Mount Toole-be-wong and others, need not be more than mentioned as they are so well known, but most of those referred to above do not appear to be much visited, although to the lover of scenery, they offer many attractions.

It might be mentioned that surmounting "Pinemont," Burt's Hill, and the "Kopje" are private houses. Permission should therefore be obtained to ascend these hills.

Rapids and Small Islands, and their Relations.

In the Warrandyte Gorge numerous rapids occur. Rapids are, as is well known, usually found in a stream, or a particular part of a stream that has not reached its grade. Streams of this nature are generally, in the language of geographers, "young," and the portion of the Yarra referred to possesses this characteristic. The valley is narrow and steep, and its bed rocky and uneven. The projecting hard rocks on the river bottom are the cause of the rapids.

These hard rocks are generally bands of sandstone which are interbedded with the softer shales. They are of silurian age, and are inclined at the moderately high angle characteristic of the silurian rocks around Melbourne. The sandstone bands are therefore parallel to the general strike of the rocks, and, as the river is constantly changing its course, the bands of hard rock, and consequently the rapids, occur at all angles to the actual direction of the river in any particular place.

As the river reaches its grade, these rapids will disappear. The river below Templestowe is fairly well graded, and rapids are generally absent.

In the same part of the river as the rapids, numerous small islands occur. They vary in size from tiny ones about a yard

in diameter to those 20 or 30 yards long. Like the rapids they are rare below Templestowe, and this fact immediately suggests a connection between these small islands and the nature of the valley in which they occur. In addition, they are found to be almost constantly associated with the rapids, and observation proves that this is not merely a coincidence, but that the cause of the rapid is also the cause of the island.

The hard rocks which form the rapids tend to project above the softer rocks, and also, at low water, above the level of the stream. These projections on their up-stream side arrest portions of the gravel sand and silt carried along by the stream. Boughs and trunks of trees floating down the river are also at times caught by the same obstacles.

The rock projections, assisted by the stranded trunks and boughs, when present, cause silting up in a small way, and a miniature island may be formed.[1] Vegetation of some kind will soon spring up, and if a strong plant such as a young shrub or tussocky grass takes root, it will increase the resisting power of the embryo island. Should the conditions continue favourable, the island increases in size and vegetation becomes stronger, until trees of moderate height, shrubs, and dense undergrowth often cover the soil and bind it firmly together.

The island thus becomes able to withstand the river, even in the winter, and becomes a definite feature of the stream. Islands in all stages of growth, from the single tussock of coarse wiry grass growing in the river, to the large island with tall trees and dense undergrowth, can be seen in the portion of the Yarra now referred to.

The formation of the island of course divides the stream into two parts, with the result that when passing the island its volume, in proportion to its space, is increased, and consequently its velocity also. The vertical erosive power of the stream is thereby accelerated, and the exposed parts of the rapids are more quickly planed down than they would be without the island. At length a temporary or permanent grade is reached, and vertical erosion ceases. Lateral erosion

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1 Small islands can of course be formed by obstacles in places other than at rapids, but the latter would appear generally the most favourable position and certainly are so in the part of the Yarra here dealt with.

takes its place, and by this means the island is gradually removed, and the rocks beneath are reduced to the general level. If a temporary grade has been reached, the same process may take place several times, until the stream arrives at a permanent grade, when the islands finally disappear. Hence the absence of islands in the lower well-graded parts of the Yarra is accounted for.

In well graded streams however, as in the Yarra near Heidelberg, numerous trunks and boughs of trees collect. At first sight, this fact would appear to be favourable to the formation of small islands, but the latter are rarely present. The explanation is apparently that a trunk or bough of a tree does not usually offer the continuous bar across the stream as a whole or in part that a band of rock does. The latter retains the silt and sand collected, whilst the former, owing to its generally tilted, uneven and often movable position, allows the current to wash around it, and so remove the material that might otherwise have formed an island.

An interesting example, however, of the formation of an island through driftwood was recorded in the "Age" newspaper on the 20th of April last. This occurred at Watts Gulch, in the Snowy River, below Orbost. The island "appears to have found a beginning in some floating debris which lodged against an embedded log at very low water. It grew gradually in magnitude with fresh accumulations of silt and debris, and is now covered with a prolific growth of vegetation, including scrub and grass, binding the soil into a compact mass. Another small island has since grown up under similar conditions." The channel was becoming blocked, and the Government agreed to expend £200 in removing the islands.

The islands in the Warrandyte Gorge grow faster in the directions parallel to the stream than across it. This is obviously due to the river keeping for itself on each side of the island as wide a passage as possible, and is somewhat analogous to silt jetties in lakes.

The formation of islands must also deflect the stream in places, causing it at times to impinge on one bank more than it otherwise would do, and thus tending to increase the curves of a stream. The course of the river is often directly influenced

by the island becoming attached to the "mainland"—that is, to one side of the valley. Actual examples of growing and of completed attachment may be seen in the Yarra above Warrandyte. If the island happens to be fairly close to one side of the stream, drift wood soon collects in quantity in the narrow channel. The current becomes checked, silt is deposited, and the island gradually becomes tied to the mainland, forming a strip of alluvial land with dense vegetation. A certain portion of the river is therefore diverted, and naturally, other conditions being suitable, the stream tends to cut into the opposite bank and form a curve. This curve may influence the whole course of the river down-stream.

The writer is not aware that the connection here noted between rapids and small islands in rivers, has been hitherto recorded.

Differential Pot-Hole Erosion.

In most text books of geology and physiography, the formation of pot-holes in the beds of streams is described, and their effect in the general erosion of the valley noticed. The writer has not, however, seen it distinctly stated[1] that this mode of erosion possesses a selective action, although this is perhaps implied in the general statement that hard rocks resist the denuding agents much more effectually than soft ones. As an actual illustration of such action has been observed, the following remarks may be of some general as well as of local interest.

The example referred to occurs in a small outcrop in the bed of the Mullum Mullum or Deep Creek, at a point immediately to the north of the Deep Creek Road, which meets the stream just after its pronounced swing round from the south-west to the north-west, near Ringwood. The rocks consist mainly of shales of medium toughness in beds from three or four inches to about three feet in thickness. Interbedded with these are bands, from one inch to three inches thick, of hard micaceous sandstone. The strike of the rocks is approximately

1 The nearest approach is in R. S. Tarr's "New Physical Geography" (1909), which contains a photograph of cascades falling (presumably over hard rocks), and excavating pot-holes in shales. The two cases however are not quite parallel.

at right angles to the direction of flow of the stream at the particular part in question, and the dip is westerly at 60 deg. Numerous pot-holes occur for a distance of about 30 feet along the stream-bed. Simple holes are generally roughly circular in outline, and vary from about three inches to over a foot in diameter (this measurement often being directly proportional to the width of the shaly beds), with an average depth of about six or eight inches. In places the holes have coalesced to form compound ones, the largest of which is about four feet in longer and two feet in shorter diameter, with a depth of about two feet. The holes are mostly confined to the shales even where two thin sandstone bands are within a few inches of one another. The softer rocks (the shales) have been selected, and the sandstones have generally resisted encroachment, with the result that the enlargement and union of holes have taken place parallel to the sandstone bands. The compound holes are often therefore narrow and elongated, and together with the simple ones are generally arranged in rows parallel to the strike of the rocks. In some instances the sandstones have been pierced both by simple and compound holes, but where the diameters are unequal, the longer one follows the line of least resistance, which is in the direction of the strike of the rocks.

There is another aspect of some interest. The height of the sandstones on the floor of the stream determines its general level of erosion, and hence the deepening of pot-holes in the shales does not directly lower the general surface of the stream-bed. Indirectly however, the erosion of the shales hastens that of the sandstones, and consequently the floor of the stream as a whole in the following manner. At low water, the sandstones project as bars above the water, which occupies the hollows in the shales. The sandstones thus become greater targets for the atmospheric agents of frost, rain and changes of temperature, than if they formed one nearly dead level. In the same way at high water and flood time, the sand and gravel carried along the stream bed, have a greater surface of sandstone to abrade than if the floor of the creek were level, notwithstanding that the hollows become partly filled with gravel, sand and other débris.

Summary.

The Nillumbik Peneplain, consisting of an elevated area—the Yarra Plateau—and a depressed area—the Croydon Senkungsfeld—is described and its age discussed.

The Croydon Senkungsfeld is shown to be a fault-block, bounded mainly by faults and their scarps. The faults traced are the Brushy Creek Fault, the Yarra Fault, and a probable fault named the Dandenong Fault. The latter has a length of nearly fifty miles, whilst the Brushy Creek Fault is traceable by its scarp for about eight miles, and the Yarra Fault similarly for about nine miles.

The uplift of the Nillumbik Peneplain was both slow and differential. It was so gradual that the Yarra was able to cut deep gorges—the Yering and Warrandyte Gorges—as fast as the land rose. The differential movement accounts for the Croydon Senkungsfeld, which is a relative and not an absolute depression.

The Yarra and Dandenong Creek Basins are divided by a line of elevated country—the Mitcham Axis—which is in part at least due to crustal movement.

The Yarra River is in a certain portion clearly antecedent to the present topography, and in its course through the Yering Gorge and part of the long Warrandyte Gorge is a revived stream.

The Yarra Flats and low adjacent country are primarily due to being part of the Croydon Senkungsfeld, through which vertical erosion almost ceased while the Yering and Warrandyte Gorges were being excavated, but lateral erosion was active.

The Yering Gorge is an isolated gorge of the Yarra, and is extremely valuable for the light it throws on the physiography of the whole district.

The Dandenong Creek and its principal tributaries are antecedent and revived streams.

The Bayswater and Scoresby Flats are within the Croydon Senkungsfeld, and belong to the Dandenong Creek Basin. Their origin is due to causes acting similarly to those which have caused the Yarra Flats.

A valley, forming part of the Croydon Senkungsfeld, stretches from the Yarra, through Croydon, Dandenong, the Carrum Swamp, and probably under the waters of Port Phillip Bay, as far as Dromana.

The composite nature and the growth of the Yarra are indicated.

The influence of the great masses of acid igneous rocks in the evolution of the topography is discussed, and a comparison made between the Upper Goulburn and Yarra Basins.

Gardiner's and Main Creeks are referred to, and the possibility of originally being distinct streams with their subsequent history is referred to.

Some monadnocks and view-points are described, and the possibility of peneplains older than the Nillumbik Peneplain is suggested.

The existence of rapids and small islands in the Warrandyte Gorge is noticed, and their relations stated.

An example of differential pot-hole erosion is given.

A list of the literature referred to is tabulated.

In conclusion, I desire to thank Prof. Skeats, Mr. F. Chapman, Dr. T. S. Hall and Mr. Griffith Taylor (now of the British Antarctic Expedition), for advice and helpful discussion on various points connected with this paper.

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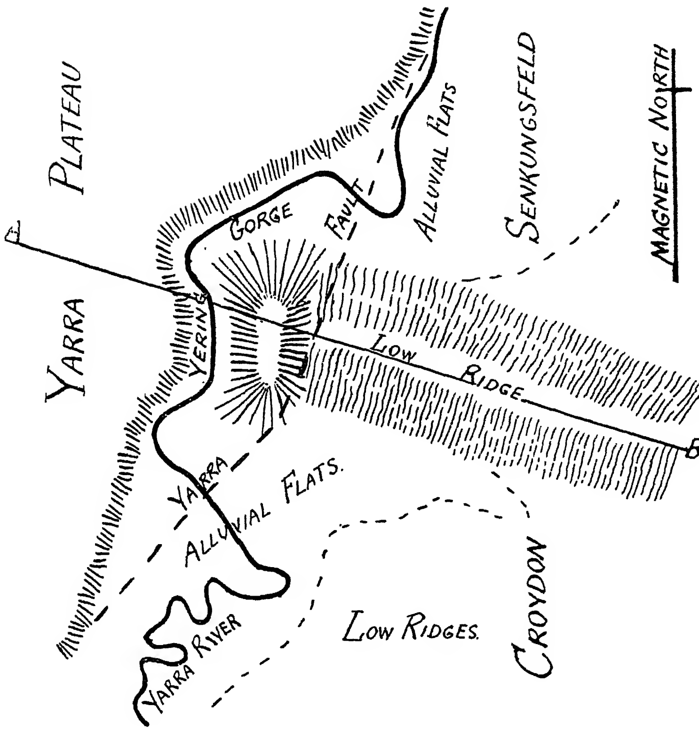

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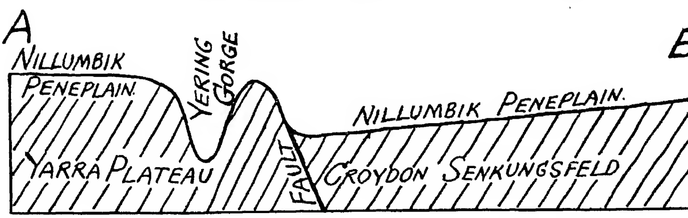

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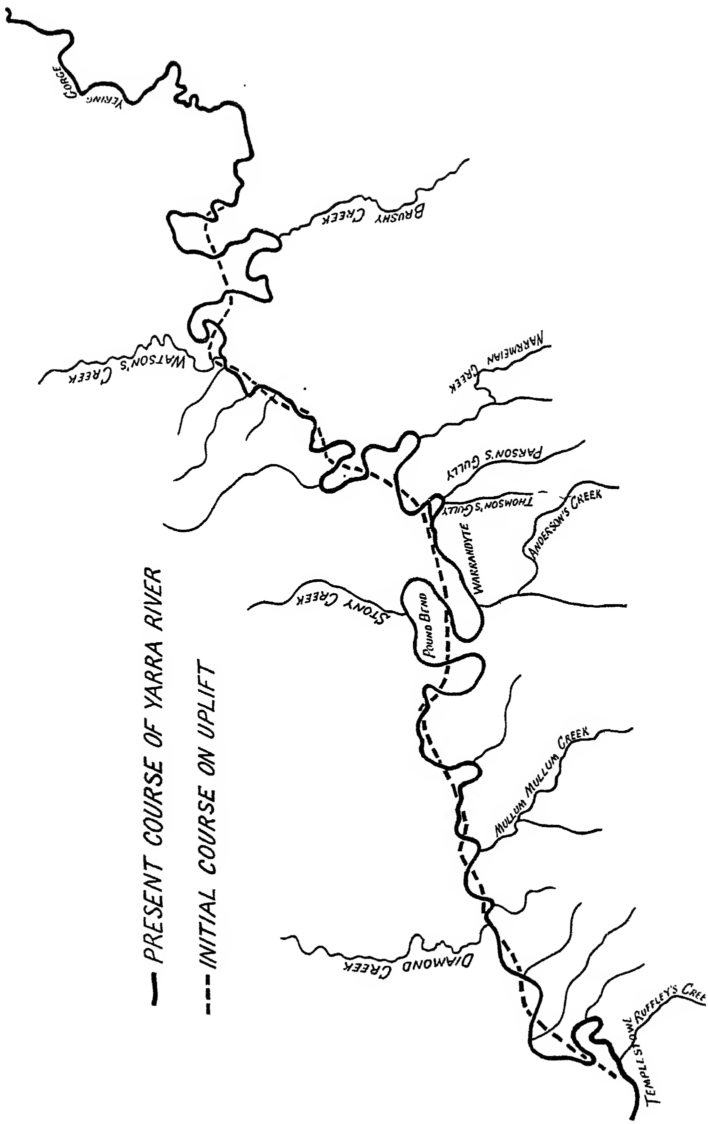
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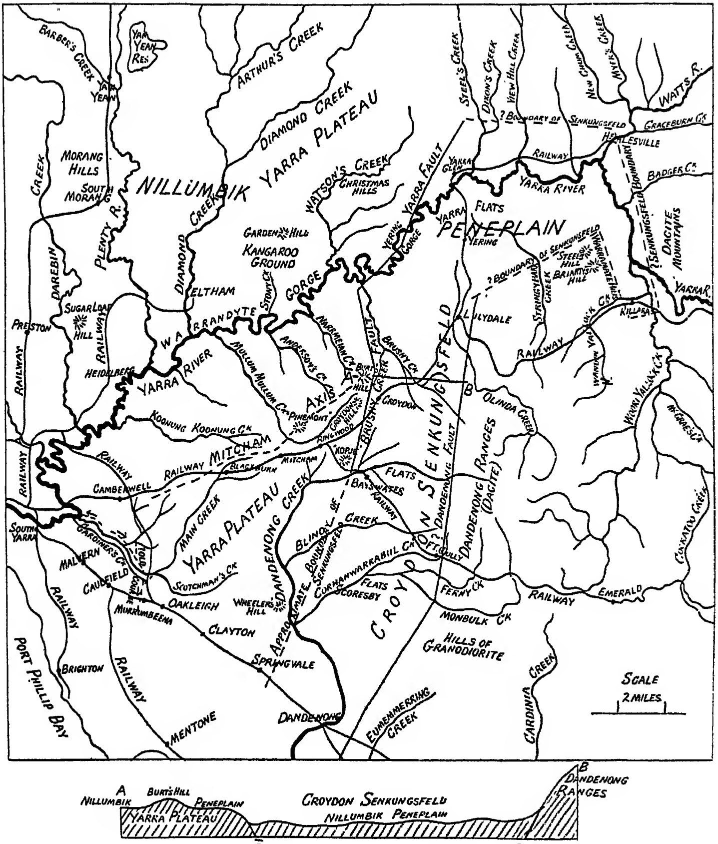
WATSON'S CREEK
NARRMEIAN CREEK
PARSON'S GULLY
THOMSON'S GULLY
ANDERSON'S CREEK
WARRANDYTE
STONY CREEK
POUND BEND
MULLUM MULLUM CREEK
DIAMOND CREEK
TEMPLESTOWE
RUFFLEY'S CRE
PRESENT COURSE OF YARRA RIVER
INITIAL COURSE ON UPLIFT



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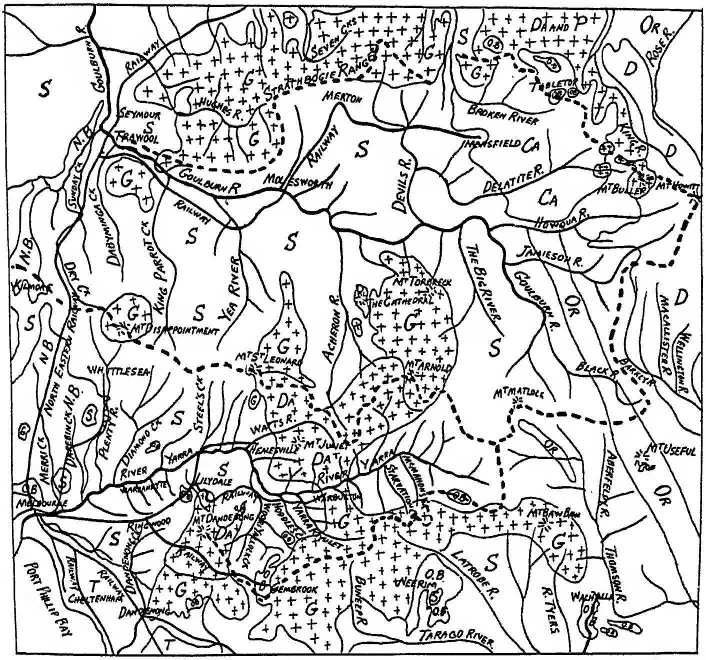

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16 MILES

++G GRANITIC ROCKS
++DA DACITES
++P PORPHYRIES
OR ORDOVICIAN
S SILURIAN
D DEVONIAN
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N.B NEWER BASALT
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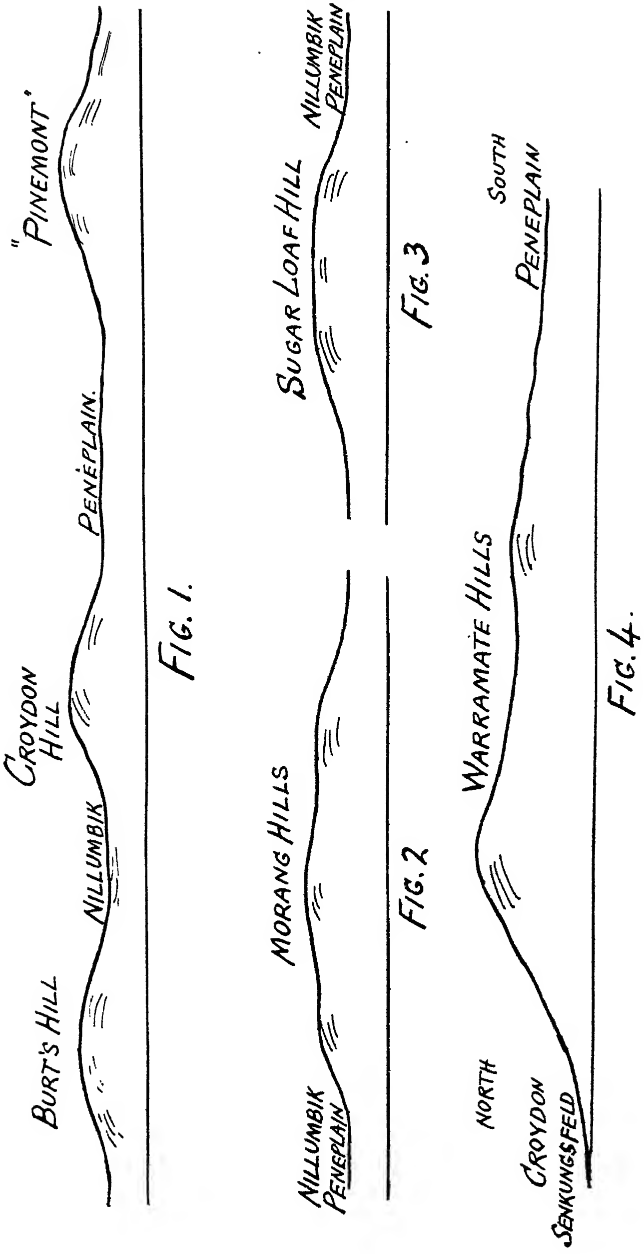

Fig. 1.

Fig. 2

Fig. 3

Fig. 4.

EXPLANATION OF PLATES.

Plate LXXXVI.

Sketch map of the Yarra River and Dandenong Creek Basins, compiled chiefly from the county map of Evelyn; with section. The diagonal lines in the latter are used for shading only, and do not indicate the nature or position of the rocks.

Plate LXXXVII.

Outline of portion of the Yarra River east of Templestowe, showing the present and initial courses of the river, since the uplift of the Nillumbik Peneplain.

Plate LXXXVIII.

Plan and section of the Yering Gorge. The datum line in the section is sea-level.

Plate LXIX.

Geological map of the Yarra and Upper Goulburn Basins, taken from the geological map of Victoria, published in 1909 by the Mines Department. All recent, postpliocene, newer and older pliocene, as well as some small outcrops of other rocks, have been omitted.

Plate XC.

Outlines of Monadnocks.

Fig. 1. Looking south from Kangaroo Ground.
Fig. 2. Looking north-west from the same place.
Fig. 3. From the east.
Fig. 4. Looking east from Kangaroo Ground.

[Proc. Roy. Soc. Victoria, 23 (N.S.), Pt. II. 1910.]

Art. XXXVI.—*The Structure and General Geology of the Warrandyte Goldfield and Adjacent Country.*

By J. T. JUTSON,

Victorian Government Research Scholar, University of Melbourne.

(With Plates XCI.-XCIII.).

[Read 8th December, 1910.]

Contents.

Introduction.

The area dealt with in this paper, as shown on one of the accompanying maps, consists of the whole or parts of the Parishes of Nillumbik, Sutton, Warrandyte, Ringwood, Bulleen and Nunawading, and is on a very rough approximation about 130 square miles. The greater portion of this district has been the subject of detailed mapping by the writer. The observations recorded and the conclusions drawn in this paper are based on this work, and therefore it will be understood that although from considerations of space the details cannot be shown on the attached maps, almost the whole of the available evidence has been obtained.

As some time must elapse before the detailed survey can be completed, and before the fossils collected and to be collected can be determined, the results to date are now brought forward.

It is hoped that the detailed map will be published later, and that sufficient palaeontological evidence may then have been obtained to adequately discuss the stratigraphy of the area.

The rocks of the district are mainly silurian sediments, and it is with them only that this paper is concerned. Some of the other formations will be considered in a separate paper; and the physiography is being similarly treated. It is sufficient here to state that the silurian rocks form a moderately dissected peneplain a few hundred feet above sea-level. The roughest ground is perhaps at Warrandyte.

Over a considerable portion of the country south of the Yarra, I have had the great advantage of the excellent topographical map prepared in 1893 by Mr. R. A. Moon. Apart from this map, one has to rely on the parish maps, which, for detailed geological work, are very insufficient; and where a series of observations has to be definitely located, rough surveys must be made. This was my experience in connection with the Warrandyte goldfield, which is mainly outside the boundaries of Mr. Moon's map. A comparison of the physical features shown on the attached Warrandyte goldfield map to the north and the south of the Yarra, shows the poverty of in-

formation on the parish map and the completeness of Mr. Moon's.

The necessity of more accurate topographical maps being prepared requires emphasis, as no entirely satisfactory detailed geological work can be done without much more correct and more complete maps. The various parish maps do not always fit together, and in compiling a larger map one has to take the mean of the discrepancies.

Previous Literature.

In 1855-56 Selwyn (1) examined the basin of the Yarra as far as where Warburton is now located, and showed that the bulk of the sedimentary rocks were palaeozoic (silurian), that they had been thrown into a series of anticlines and synclines, that auriferous quartz veins occurred, and that a conglomerate and breccia (both fossiliferous) were found at Anderson's Creek. His estimate of the thickness and relative age of the various beds will be mentioned subsequently in treating those subjects. The remarkable map accompanying Selwyn's report will always be the basis for all future work in the Yarra Basin.

In 1855 William Blandowski (2) briefly described and figured some fossils from Anderson's Creek.

In 1866 Selwyn (3, p. 12) referred again to the fossiliferous breccias. The geological sketch section accompanying his report showed the silurian beds from Yan Yean to Mt. Juliet folded into a succession of anticlines and synclines.

In 1893 Mr. R. A. Moon (4) made a topographical and geological survey of a large area of the country to the south of Warrandyte, which is included in this report. From a topographical standpoint this map is of great value. Every gully and every hill and ridge are shown with great accuracy, and in traversing the country I could fix any position with the utmost precision. Mr. Moon's available time was evidently so absorbed with the topographical work, and with indicating quartz reefs, that he was not able to deal much with the general geology. No serious attempt was made to grapple with the structure of the district (although he indicated a probable line of anticlinal from Tunstall to near Warrandyte,

with another short anticlinal line, and various dykes); and sections that required care and time to correctly determine were (wisely, I think, under the circumstances) omitted. In addition, since the issue of the map many more road and quarry sections have probably become available. Many sections, however, that could easily be missed were recorded by Mr. Moon, and it is a pleasure to acknowledge my indebtedness to him in this direction, and for the topography.

In 1894 Mr. R. A. F. Murray (5) reported on a brief inspection of Panton Hill, Queenstown, and other localities, and referred to the anticlinal fold along which at Warrandyte and Anderson's Creek, the principal gold discoveries had been made.

In 1895 Mr. James Stirling (6) briefly reported on the parishes of Warrandyte, Nillumbik, Greensborough and Queenstown, which had been rapidly surveyed by Mr. O. A. L. Whitelaw. Some sketch geological maps were issued, but the parish of Warrandyte was not included.

In 1896 Mr. Murray (7) reported briefly on the reefs at Warrandyte, and on an auriferous dyke on the south side of the Yarra.

In 1898 Mr. Walter Forbes (8) showed that the Warrandyte mining belt of country formed a series of anticlines and synclines, which he represented by map and section. He mentioned that bands of conglomerate were noticeable, referred to two auriferous dykes, and gave particulars of the strike, thickness, yields, etc., of the reefs. He also drew a section across the goldfield showing the numerous folds, but without reference to the structure of the surrounding country.

In 1902, Professor Gregory (9), in subdividing the silurian rocks of Victoria into the Melbournian and Yeringian series, referred to a great anticlinal, which he called the Warrandyte anticlinal, the axis of which passed through Warrandyte. He stated that along this axis was a line of contortions and faults (the "Warrandyte Fracture Zone"), along which a series of auriferous quartz reefs occurred. He classified the beds forming the Warrandyte Anticlinal as of Melbournian age (Ib. fig. 5, Plate XXV.).

In 1905 Mr. E. J. Dunn (10) reported on the Caledonia Gold Mine, with brief references to other reefs.

In 1907 Mr. A. M. Howitt (11) reported briefly on some reefs at Warrandyte, and noted a fossiliferous locality, and a basic dyke.

The Silurian Rocks of the District generally.

(a) *Area.*

With the exception of the older basalt at the Kangaroo Ground and some tertiary gravels, silurian rocks occupy the whole of the country here dealt with.

(b) *Petrology.*

The rocks of the district show little variation in lithological character. They consist mainly of shales with sandstones of varying degrees of coarseness. The shales are perhaps the most predominant. Throughout wide areas they are thick-bedded and massively jointed, as well as extremely rubbly. Bands of sandstone, generally from 3 to 12 inches thick, are sparsely interbedded with them. Occasionally sandstone bands up to 6 or 8 feet in thickness are met with; but they, as well as continuous sections of the same rock, are rare. Mica (generally muscovite) is extremely common in both the shales and sandstones, but in the latter rocks the flakes are larger, and therefore more noticeable. Many of the shaly rocks are when undecomposed, moderately tough, but on exposure they soon soften and break up.

The sandstones have been so silicified in places as almost to have become quartzites. Almost the only rocks that can be called quartzites occur in a narrow band of rocks running from the "Kopje," through Burt's Hill, and along the western side of Brushy Creek. Silicification has occurred all along this line, but only in parts have true quartzites been produced. The grains of the rocks in this band are finer than in most sandstones elsewhere met with. Slates are almost wholly absent from the district.

In the immediate neighbourhood of Warrandyte, conglomerates, grits and coarse sandstones are associated with the shales. The coarse-grained rocks outcrop on the ridges and slopes, par-

ticularly at Fourth Hill, a long ridge forming the crown of the main anticlinal fold of the district, along the axis of which most of the principal quartz reefs occur. An erroneous impression is likely to be obtained that these coarse-grained rocks are the predominant ones; but a careful inspection of the country and a glance at the mining dumps show that the shales and sandstones are by far the most common. Dr. T. S. Hall (12, p. 58) has referred to a somewhat similar instance at Castlemaine, although there is little accumulation of loose blocks in the valleys at Warrandyte. The coarser-grained rocks however, where they form a moderate proportion of the strata, largely determine the rate of denudation of the hills.

The conglomerates and grits vary in thickness from a few inches to about 12 feet. With one exception they cannot on the surface be traced more than about 100 yards, and usually less than that. In most cases they seem to pass rapidly into sandstones and shales, both along their line of strike, and in their vertical succession. Alternating sections are common. The rocks vary from fine grits to conglomerates, containing pebbles up to 3 or 4 inches in diameter. In the coarser rocks the pebbles are well rounded and water-worn. In the grits they are angular, and appear to have travelled little distance. The pebbles are of quartz, quartzite, sandstone, and flint or chert, quartzites perhaps being as abundant as any rock. Most of these rocks, as well as some sandstones and shales, are calcareous; but much of the lime has been leached out. The conglomerates are in places exceedingly tough; and project in boulders above the surface of the ground. Others are soft and friable, and would not be noticeable except for artificial sections. Quartz veins occur, but usually about $\frac{1}{8}$ or $\frac{1}{4}$ of an inch thick, and in the hardest conglomerate are almost absent.

The only conglomerate that can be traced any distance is one seen in section in Whipstick Gully, near the Victory mine. It is here about 12 feet thick, and is a tough, dense grey rock when fresh. It differs from most conglomerates of the district in having comparatively few, but always well-rounded, pebbles set in a fine matrix. This, and its mode of weathering into large boulders, enable it to be readily traced. It is found on both sides of Whipstick Gully and of Anderson's Creek. Its

distribution will be dealt with when treating of the geological structure. Almost all the coarser-grained rocks are fossiliferous.

(c) *Geological Structure.*

Folds.—The principal structural features are the anticlines and synclines, into which the whole of the silurian rocks of the district have been thrown. There are great folds which embrace a wide area, and which can be traced along the strike of the rocks considerable distances. Sometimes they give place to smaller but more numerous folds. The main anticlinal lines at times bear on their crests smaller folds, which in some instances are not very much compressed, the legs being at moderate angles; in other cases the pressure has been so great that the legs are almost vertical, but no example of inversion has been observed. The minor folds seem to soon run out along the strike of the rocks. Where there is a main anticlinal fold, with numerous smaller ones on its crest, fracture of the rocks, as would be expected, has taken place, and so channels have been opened for the deposition of quartz, gold and other minerals. The generally short courses of the subsidiary folds probably account for the restriction of quartz reefs in a meridional direction. The general strike of the rocks would average about 15 deg. east of north.

Treating the folds in more detail, a traverse from Templestowe through Warrandyte to the north of Croydon shows that at Templestowe an anticline, which, in its principal or subsidiary folds, has been traced south to the Koonung Koonung Creek, and north to the northern boundary of the parish of Nillumbik (crossing the Diamond Creek to the south of the township of that name), a distance of nine miles. At Templestowe two sharp minor anticlines occur, which may be regarded as folds in the main axis. The reef containing gold and antimony, that has been worked at Templestowe with unfortunately, (in recent times at least), non-payable results, probably occurs on one of the minor anticlinal folds. The western limb of the anticline is much contorted in places, as may be seen on the main road between the Plenty River and Eltham, and on the Eltham railway line. The anticline here described may conveniently be referred to as the Templestowe Anticline.

The next fold to the east is that of the great syncline, whose axis crosses the Yarra River between the Diamond and Mullum Mullum Creeks. It has been traced for the same distance and between the same boundaries as the Templestowe Anticline. This structural feature has been named the Bulleen Syncline, from the parish in which it is so well developed. It is a broad fold, having a great thickness of rocks developed in its septa, particularly the eastern one. From the axial line, the westerly dip can be traced right into Warrandyte township, a distance of four miles in a straight line. This septum forms the western leg of the next great anticlinal fold, that already known as the Warrandyte Anticline.

This fold consists of one great arch, with five minor anticlines and four minor synclines on its crown at Warrandyte. In this district it is a geanticline, but this feature is not retained either to the north or to the south. These minor folds comprise Professor Gregory's "Warrandyte Fracture Zone," and scarcely extend beyond Anderson's Creek, Parson's Gully and the Yarra, except where one becomes the main axis to the north or the south.

The eastern leg of the Warrandyte Anticline has been traced with a regular easterly dip from Warrandyte south-easterly to a little to the north of Croydon, a distance of about 3½ miles; and may possibly extend farther eastward. In this limb the amount of dip keeps fairly constant; but in the western leg, minor puckers and nearly horizontal strata occur, which indicate lateral pressure of insufficient strength to form more folds. At Melbourne Hill, near Warrandyte, on the old main road, and on the main Warrandyte-road, just east of Newman's-road, miniature anticlines and synclines, and strata of low dip are exposed. Rocks nearly horizontal also occur along the Yarra west of Pound Bend, and in a series of quarries along Ruffley's Creek. These features however do not affect the general westerly dip. The eastern limb of the Warrandyte Anticline is generally of higher dip than the western in the locality under consideration. The latter would perhaps average about 40 deg. and the former about 60 deg. This would tend to incline the axis to the west, which is what actually occurs at the Caledonia Mine, according to the surveys of the mine.

The Warrandyte Anticline extends, so far as my observations go, from Tunstall to the north-east corner of the Nillumbik Parish at Watson's Creek, a distance of twelve miles; but it does not consist of one unbroken axial line, nor does it retain the great thickness of its septa, which, as already stated, exists to the east and west of the axis at Warrandyte.

Taking the minor folds of the crown of the anticline from their western side, the first and second anticlines are the only folds that can be traced any distance to the north or the south; and these really constitute the main axis of the great arch. The second one, which carries the main line of gold workings at Warrandyte, may be followed to Tunstall, where it becomes one of several normal folds. Northerly it crosses the Yarra to the west of the island, and is traceable further north to the large bend in the Yarra near the Caledonia Mine. Here it may be thrown to the east by a fault, and if so, as shown on the map, its further course is short and it dies out altogether.

The main axial line of the Warrandyte Anticline appears to be continued to the north in the first minor anticline. This commences a little south of the Yarra, and has been traced to Watson's Creek at the north-west corner of Nillumbik Parish. Its further extension has not been observed. From being a minor fold at Warrandyte, it rapidly becomes a great anticline, which does not however retain its geanticlinal features, nor the great thickness of both limbs, as the section along the line AB of the map of the whole area shows. Between the axis of this anticline and that of the Bulleen Syncline, a normal syncline and anticline occur. The eastern limb has a thickness of about 8000 feet, and its limit has not yet been determined. This limb is disclosed in two splendid sections, about one mile and one and a quarter miles in respective lengths, along the Maroondah Aqueduct. The gap between these sections is filled by the dips available at Watson's Creek, and thus a practically continuous section about three miles in length is obtained. This section is remarkable for the great regularity and unbroken character of the strata. This feature is applicable to the limbs of the folds in the district generally. Intense squeezing has taken place fairly often, but it is as a rule restricted to the axial lines, and generally to the anticlines. From casual

observation, it might be thought that the structure was often hopelessly tangled, but detailed examination proves that this is not so. The other minor folds of the Warrandyte Anticline are short and restricted to the vicinity of Warrandyte. The dips along the line of dyke east of the Caledonia, and also of the country further east, are all easterly with generally a north-westerly strike, thus converging towards the strike of the axis of the second minor anticline. On the northern bank of the Yarra opposite the Caledonia Mine, the dips are not too clear, but so far as they go, the two converging lines of strike have met here to form a single fold, with the minor folds to the south and east cut out. This single fold is apparently faulted to the east; it then runs north-easterly for a short distance, but soon dies out, as before mentioned. The strike of the rocks however continues to the north-east.

The structure therefore at Warrandyte appears to be a great arch, on the crown of which are several minor anticlines and synclines. The two most westerly anticlines are preserved to form the main axis of the fold to the north and the south. This axis thus becomes disconnected at Warrandyte. The minor folds to the east of the main axis appear to merge into one fold to the north of the Caledonia Mine, giving a fan-shaped structure, the fan opening unequally from north to south. A strong northerly pitch near the river at Warrandyte has accentuated the structural form. By way of contrast, the structure may be considered along a line roughly parallel to the railway from Blackburn to Croydon, which shows a normal order. Beginning at the former place, there are, as shown on the map, the Blackburn Anticline, the Tunstall Syncline, the Warrandyte Anticline, the Mitcham Syncline, and the Ringwood Anticline, with other small folds further east. The named folds are normal to one another and regular, although some minor puckers are found on their axes. Thus the great arch at Warrandyte becomes in its southern portion split up into five normal folds at least.

The distinctive band of quartzitic sandstones occurs along the outer part of the eastern leg of the Warrandyte Anticline, and it is of interest to see how the strike runs north-easterly to Croydon, then gradually swings round to the north-west, and

is traced along Narrmeian Creek to the Yarra where, as before noted, the strikes converge and one fold results, after which the strike becomes north-east again.

Associated with the minor folds at Warrandyte are the conglomerates, grits and sandstones that have been already described. These conglomerates and grits, wherever observed, are conformable to shales and sandstones, and there is no evidence of any unconformity between the beds, nor can any base be detected.

The outcrops of the conglomerates are numerous, and occur on most of the folds, but the only distinctive one is that already referred to. This is found on both sides of Whipstick Gully and on the northern side of Anderson's Creek, folded round the axis of the second minor anticline, and passing into Third Hill and through Fourth Hill.

The axis of the fold at Whipstick Gully has a strong pitch, the crown of the conglomerate at the axial line being lower on the northern side than on the southern. This pitch probably accounts for its non-outcrop farther north.

The conglomerate has a steep easterly leg and a more gentle westerly one, thus illustrating the general nature of the main fold. On the left side of Anderson's Creek, a disconnected band of the conglomerate runs south-westerly parallel to the creek for about 200 yards. Its outcrop ceases at the next tributary gully; but whether from faulting or from passing into finer-grained rocks, cannot be stated. This band is, from the dips in the vicinity, on the eastern leg of the anticline, but is not in a direct line with that on the opposite side of the creek. The western leg does not outcrop, but may be covered by alluvium on the right bank of the creek. Faulting has probably occurred here, and caused a displacement of the conglomerate to the east; but it cannot be very much, as the axial lines of the anticline continue southward with practically no deviation.

This conglomerate has not been found on any of the other folds. This may be due to faulting, or to occupying a small area, or to a change in its lithological character, probably to one of the two latter, as faulting on a large scale does not seem to have much occurred.

With regard to pitch generally, in the southern portion of the area, no widespread pitch occurs. In places there is possibly apparently small local pitch, but this may be due to the running out of the anticlines or synclines, and not to crustal movements.

The pitch of the rocks at Warrandyte has been already noticed, and this pitch appears to continue north-easterly along the axis of the Warrandyte Anticline to Watson's Creek, a distance from Warrandyte of five miles. It is well seen where the axis crosses the Maroondah Aqueduct, at which point the beds are pitching to the north-east at an angle of 40 deg. At Watson's Creek the feature is repeated, the angle here being 35 deg. At the latter locality the sections are particularly instructive. Almost a semi-circle in the direction of the strike can be traced from the western leg of the anticline, through its axis to the eastern leg.

This strong pitch together with the eastern and western limbs of the Warrandyte Anticline, gives at Warrandyte three sides of a great dome. A strong southerly pitch towards Ringwood would complete the dome, but this does not exist. At one time such a pitch may have existed, but the latter may have been destroyed by subsequent differential movements. Of this there is no evidence, except that which may have formed the Mitcham Axis (details of which are given in the separate paper dealing with the physiography of the district), and which would probably not be sufficient to obliterate any pronounced pitch.

Faults.—These do not appear to be important. Numerous small dip faults occur at the Caledonia Mine, as will be described later. That in the conglomerate at Anderson's Creek is also a dip fault, but the horizontal displacement of the rocks may be calculated in yards. Strike faults probably occur in the mines along the reef channels. Casts of slickensides in quartz in various parts of the area outside Warrandyte prove movement. Most of the latter appears to have been vertical. That it at times was much from the vertical is shown by the almost horizontal slickensides noticed in some quarries on Ruffley's Creek. No evidence, however, of any movement that has caused a great displacement has been obtained. Although fractures are numerous in connection with the folds (as at Warrandyte),

yet much slipping does not appear to have taken place. This is shown by the repetition of the grits and conglomerates at Warrandyte, which from the general appearance of their fossil contents, and their lithology indicate their connection with one another. A possible line of faulting is the main dyke east of the Caledonia mine, which has been traced several miles, but for the reasons given when treating of the cause of the horizontal limitation of the Warrandyte field, this is probably a fracture with little displacement. The general structure of the country as above indicated, suggests that no important movement has taken place along this line.

An important fault, but belonging to a much later period than the folds and fractures of the silurian rocks generally, is marked on the map as the Brushy Creek Fault. This is fully dealt with in the paper on the physiography of the Yarra River and Dandenong Creek Basins, and need not be further discussed here.

Dykes.—The principal one is that noticed under the preceding section; a little to the east is another one. They are indicated on the accompanying maps so far as traced by the writer, but one, according to Mr. Whitelaw's geological map of part of the Nillumbik Parish, runs as far as Kangaroo Ground. They are about 8 or 10 feet wide and dip to the east, the more westerly one at 60 deg. and the other at about 45 deg. The rock is so decomposed that it cannot be determined. The dykes contain thin auriferous quartz veins. Other dykes are marked on Mr. Moon's Quarter Sheet, and others occur near Croydon, where they have been worked for kaolin.

Mr. A. M. Howitt (11, p. 40) discovered when at Warrandyte a basic dyke about 2 feet in width in the Caledonia Mine cutting across a cross-course. The rock was fairly fresh, and enabled Prof. Skeats to determine it as a monchiquite.

Joints.—These in general call for no special remarks. In most cases they do not pass continuously through different rock beds. Dip and strike joints are sometimes fairly well developed, and in thick-bedded homogeneous shaly rocks cause great difficulty in determining the dip. Some points of interest in connection with joints may be noted.

Some of the vertical joints are so close together that they have the appearance of incipient cleavage. At a quarry on the Mullum Mullum Creek, there is a band of rock about 2 feet 6 inches broad and about 15 feet high, divided into regular vertical lines from 1 to 3 inches apart. No other division planes are visible. On each side of this band ordinary well marked bedding planes are developed with vertical joints a little distance apart. On close examination similar rocks are seen to continue across the particular band. The jointing has been so minute and regular as to obliterate the bedding planes in this portion of the rocks. Curved joints are found above the entrance tunnel at Pound Bend. In no other locality in the area have I noticed similar joints.

The most interesting jointing is in connection with the conglomerates and grits at Warrandyte. Some of these rocks are fairly tough. When jointed, even in blocks 3 or 4 inches in size, the hard quartz, quartzite, chert, and sandstone pebbles are often seen to be cut through as smoothly and evenly, as if they were plastic materials cut with a knife. That this is simply due to jointing is shown by the absence of slickensides, and by the very small and close planes that occur. It proves that the force exerted was enormous. De la Beche (13, p. 628) notices the same feature in the conglomerates of the Old Red Sandstone in the County of Waterford, Ireland, where "huge masses of the conglomerate, composed of quartz pebbles and of portions of older arenaceous and other deposits, as also of igneous rocks, in certain localities, may be smoothly cut through and separated by joint planes." He also states that the division presents no trace of dislocation or movement, the faces of the divided parts of the pebbles fitting each other exactly. When the Warrandyte conglomerates are broken with the hammer, the fracture is irregular, leaving the pebbles intact.

(d) *Fossils and Conditions of Sedimentation.*

At Warrandyte in the coarser grits and conglomerates, fossils are often abundant. They consist mainly of corals and polyzoa, but the species are apparently not numerous. The old Victorian Geological Survey found some fossils in the finer grained rocks,

but they are presumably scarce. Outside the Warrandyte district a trilobite, probably an Illaenus, and some brachiopods and corals have been found. The fossils have not yet been examined, so little can be said with regard to them.

The sediments indicate that at Warrandyte there was an old silurian shore line, close to which the conglomerates, grits and sandstones were laid down. These are also interbedded with shaly rocks, the alternations often being very rapid, thus showing shallow-water conditions. To the south of Warrandyte these coarse rocks seem to gradually pass into those of finer grain. A strong pitch conceals their northward extension, while they do not occur to the east or west, by reason of passing beneath the great mass of rocks that form the Warrandyte Anticline. Possibly their extent horizontally was never very great. The direction of the old shore line cannot be indicated, and all that can be said at present is that it was probably not to the south.

On the top of the shallow-water beds is a great thickness of shales, occasionally separated by thin bands of sandstones. These by their general absence of coarser material (in one or two places a thin band of grit or conglomerate has been found) appear to have been laid down in moderately deep water. On the top of these in the Croydon district is the narrow band of silicified sandstones. In the western part of the area the thick shales are succeeded by rocks of the type seen near Melbourne, alternating sandstones and shales. From the great thickness of the shaly rocks, it is evident that there was a gradually-sinking shore line, with which however the sedimentation kept place, and so prevented very deep-water conditions from resulting.

(e) *Age and Thickness of the Rocks.*

Pending the examination of the fossils, nothing definite can be said as to the age of the rocks throughout the area. Prof. Gregory has indicated (9, Plate xxv. Fig. 5) that the rocks of the Warrandyte Anticline are of Melbournian age, and has also suggested (Ib. p. 172) that the Yeringian series might be expected to appear in the syncline to the west of the Warrandyte Anticline) i.e., the Bulleen Syncline).

In 1856 Selwyn (1, p. 11), referring to his section across country, part of which is included in this paper, stated on purely stratigraphical grounds that the lowest portion was exposed in an anticlinal axis west of the Diamond Creek (i.e., the Templestowe Anticline), and the highest beds occurred immediately east of the River Yarra and west of the River Plenty.

On the field evidence, without determination of the fossils, I should place the Warrandyte grits and conglomerates as the oldest, and, going westerly, gradually rising until the youngest would be along the axis of the Bulleen Syncline, although there is no evidence yet to state that these are Yeringian. The beds of the Templestowe Anticline would be between these two, and therefore of about the same age as the middle beds of the western limb of the Warrandyte Anticline. Mr. Chapman records (17, p. 66) *Chonetes melbournensis* Chapm., from near Templestowe, and he informs me that this fossil has not been found outside the Melbournian series. If the Templestowe beds are Melbournian, the Warrandyte beds may be still older, or perhaps some faulting has occurred at Templestowe which has not been detected.

South-east from Warrandyte, the beds should become younger, until the youngest of the area would occur a little to the north of Croydon.

As there is apparently no pitch along the Warrandyte Anticline between Warrandyte and Tunstall, the beds at the latter place, unless there be some undiscovered dip faults, should be about the same age as those at the former locality.

The strong pitch northerly of the same great anticline should bring beds younger than those at Warrandyte to the surface at Watson's Creek in the north-east corner of Nillumbik Parish. The thickness of the rocks disclosed by the pitch along the axial line has not been estimated, so that their approximate position in relation to the other beds cannot be stated.

The fossils will of course ultimately have to definitely settle these questions, in conjunction with the field evidence.

Concerning thickness, Selwyn (1, p. 11) states that the greatest ascertained thickness of the beds along his line of section is 10,900 feet. According to the writer's calculations,

along the main undivided limbs of the Warrandyte Anticline (south-east and west of Warrandyte) the thickness of the rocks on the eastern limb is between 14,000 and 15,000 feet (allowing an average inclination of 60 deg.), while on the western (allowing an average dip of 40 deg.), it is between 12,000 feet and 13,000 feet.

Future research, especially in palaeontology, may discover that the beds are repeated by faulting, and this would of course reduce the thickness. The sections, however, on which the estimates are based are very continuous, and faulting is the only feature that could reduce them. The folds are so broad that inversion need not be considered.

(f) *Denudation.*

Judged by the estimated thickness of the beds forming the Warrandyte Anticline, there has been a minimum denudation at Warrandyte, prior to the dissection of the present peneplain, of over 12,000 feet vertically.

(g) *Character of the Rocks from which the Silurian Derived.*

Conglomerates are always of interest in the light they shed on the derivative rocks. At Warrandyte many of the sandstones and grits contain such an abundance of mica (mostly muscovite) as to suggest their derivation from an igneous rock. No such pre-existing rock outcrops in the district, and the conglomerates, so far as examined, have not yielded any pebbles of it. The constituent pebbles consist of quartz, quartzite, sandstone, and flint or chert, quartzites and sandstones being perhaps most abundant. The sandstones consist mainly of quartz grains, and so throw little light on the subject. It is evident therefore that the rocks which were broken down to form the conglomerates consisted largely, if not wholly, of altered and unaltered sedimentary rocks. No trace of these has yet been discovered.

The Warrandyte Goldfield.

(a) *Geological Structure.*

The main features have already been indicated under the geological structure of the whole district. To briefly recapitulate, there is a great anticlinal fold (the Warrandyte Anticline), which has five minor anticlines, and four synclines on its crown. The quartz reefs are intimately associated with these minor folds, and as frequent reference will have to be made to the latter, it is as well to use distinctive names.

As mentioned above, the most westerly minor anticline is really the northern continuation of the main axis of the whole main anticline, and the next minor anticline to the east occupies a similar position in the south. These minor folds have in the description of the geological structure of the district been referred to as the first minor anticline, and the second minor anticline, respectively. The most westerly fold can be called the Main North Anticline, and the next easterly anticline similarly the Main South Anticline, both being parts of the Warrandyte Anticline. It is in connection with the portions of the folds at Warrandyte that the terms suggested will be chiefly used. The short syncline between the two folds mentioned need not be named. Following the Main South Anticline to the east is the Caledonian Syncline, then Thomson's Gully Anticline, then a short synclinal axis, which requires no name, then the Consols Anticline, then an unnamed short syncline, and lastly the Fifth Hill Anticline. The names used (except for the first two anticlines) signify the reefs or physical features with which the folds are respectively connected. The enlarged map of Warrandyte shows the directions and lengths of the folds as traced.

The general relations of the minor folds to the major one have already been discussed. It will be noticed that the three anticlines east of the Main South Anticline tend to approach the latter and one another as they are followed to the north, and also that from west to east they become shorter at their

northern ends. The explanation appears to be that the lateral pressure which produced the folds, produced different results. At Warrandyte a great arch was formed, but the pressure continuing, the strain was relieved in one part of the field by the wrinkling of the crown of the arch. A little to the north, great pressure seems to have come from the east, with the result that the strata of the eastern leg of the great fold were bent towards the central axis, and acquired a north-westerly strike, losing their normal strike, which is north-easterly. The several small folds which occur to the south, appear to have been squeezed towards one another, and eventually to have merged in the northern continuation of the Main South Anticline. Farther to the west the fold of the Main North Anticline commenced. This anticline, where it overlaps the Main South Anticline, may be due to the pressure from the east already mentioned.

To the north of the area where the strata are squeezed to the north-west, the strike becomes north-easterly again, as shown along the Yarra towards Watson's Creek. The anticlinal axis which crosses a great bend of the river, as shown on the enlarged map of Warrandyte, although represented by a fine fold on the river bank, soon dies out to the north, whilst to the south, an east and west line would join the southern end (so far as traced) of this fold and the northern end of the Main South Anticline. This fact, together with the difference in the strike of the rocks, suggests a fault along this connecting line, caused by the intense pressure from the east, of the strata which now form the northern end of the Main South Anticline.

To the north of Warrandyte, the pressure relaxed, with the result that the axial lines widen, and the Main North Anticline develops into a broad fold with a western leg divided into two normal folds, whilst the eastern one is undisturbed and unfractured for several miles.

To the south of Warrandyte, normal folds have resulted without any intense folding or contortion.

At Warrandyte, therefore, the great pressure has caused the formation of a number of small folds along which, as would be expected, fracture has taken place. Thus Prof. Gregory's

" fracture zone " is justified, but the cause of that fracture zone, and its relations to the rocks of the surrounding country, have not hitherto been determined. The distribution of the quartz reefs, and their connection with the geological structure will be subsequently discussed.

(b) *The Quartz Reefs.*

These have been individually described in 1896 by Mr. Murray (7), and in 1898 by Mr. Walter Forbes (8). The latter gives full particulars of the reefs then known, as to strike, dip and thickness of beds, etc. It is therefore unnecessary to deal minutely with the reefs, even if that were possible, which it is not, as at the time of my visit to Warrandyte most of the later mines were closed down, and the old workings are as a rule inaccessible to any depth. The purpose kept in view during the examination of the country, was not to record minute information as to particular reefs, but to endeavour to grasp the relation of the reefs to geological structure, and by this means to throw some light on the cause of their distribution. A general account will therefore be sufficient, unless there be any points of special interest.

The reefs are associated with the minor folds, and generally with the anticlines, although the Caledonian and Bendigo lines are in the Caledonian Syncline. They are approximately parallel in strike to the direction of the axial lines, but at times cut across the strata at slight angles. Their strike varies from about N. 10 deg. E. to N. 25 deg. E. Their underlie is sometimes to the east and sometimes to the west, generally close to the vertical. They are usually thin, ranging from about 3 inches to 2 feet, the majority probably being under a foot in thickness. Most of the workings are shallow, not exceeding 200 feet in depth, and being very little below the ground-water level. The deepest mines are the " Victory " (whose greatest depth was about 275 feet) and the " Caledonia " (600 feet). The quartz is in places fairly well mineralised.

The lengths of the reefs, so far as ascertainable, appear to correspond in length with the folds of the rocks, or those portions of the folds that have been subjected to great pressure.

Thus the Main North Anticline dies out a short distance south of the Yarra, and no reefs appear to be there. North of the river, however, are the Loyal Liberal and other reefs, but the latter become scarce as the anticline widens out. The Main South Anticline has the main line of reef. It has been traced from the "Great Southern" reef (south of Anderson's Creek) through the Fourth, Third, Second, and First Hills to the northern side of the river, just west of the Caledonia mine. Farther to the north-east where the short anticlinal axis already referred to crosses a great bend of the river, a reef about 18 inches wide occurs. In the Caledonian Syncline two lines of reefs (the Caledonia, and the Black Swan-Bendigo lines) are traceable for a considerable length of the syncline. Thomson's Gully Anticline shows few workings, as the fold is short. The Consols Anticline has fairly continuous workings, and at Fifth Hill the reefs agree in length so far as traced.

A further point of interest is the distribution of the reefs in connection with the more westerly of the two auriferous dyke east of Warrandyte. This dyke runs in a north-westerly direction, and the reefs run from the south-west, and would meet the dyke if extended. So far as known, no reefs cross the dyke south of the river. The relations of the reefs to the dyke and to the folds will be discussed later.

The main line of reefs is mostly in the eastern leg of the Main South Anticline, but very close to its axis. Along the top of Fourth Hill, no well-defined reef has been worked, most of the workings being in thin apparently disconnected veins. The Caledonia is practically along the axial line of the Caledonia Syncline, while the Bendigo, Consols, and Fifth Hill lines are in rocks dipping westerly at the surface.

Various cross-courses have been described by Mr. Forbes. Some I have verified, others I have not from want of accessibility. These do not call for any detail. Thin-bedded veins are found in various parts of the field. Sometimes they fault the reefs, and are therefore subsequent to them. The reefs are generally moved only a few inches or a few feet. The bedded veins here indicate small movements along the bedding planes. These veins are said to have an influence in places on the deposition of gold, as will be mentioned later.

The mines that have been developed since Mr. Forbes' report are the Victory, the Caledonia and the Consols, which are now all closed down. Others, such as the Reward, North Caledonia, South Caledonia and the Blocks, were abandoned after very little work, so far as can be ascertained. The Consols is the old "Pigtail" reef, and the Victory has been worked mainly under Third Hill. The Caledonia is of interest structurally, and some details will therefore be given. For much of the information concerning the structure of the mine I am indebted to the plans of Mr. A. H. Merrin, M.C.E. (now Chief Inspector of Mines), and Mr. H. Herman, B.C.E., to both of whom I wish to tender my thanks for permission to refer to the same. The responsibility for the reading of the plans and for any conclusions drawn from them, is my own.

The Caledonia Mine has been reported on by Mr. Dunn, but since his visit the mine was much more opened up. The main shaft has been sunk to 600 feet, but little work has been done there, as the stone did not prove payable. The reef in the top levels underlies to the west, but turns to the east in the lowest level. I believe however that a winze showed that it soon became westerly again. It occurs in the Caledonia Syncline, whose axis dips from the vertical to the west. The rocks have a strong northerly pitch. Faults, cross-courses and "splices" occur in the first and second levels, and are almost wholly left-hand breaks (i.e., going north, the reef, where a break occurs, is found again to the west). The "splices" occur mainly in the top level, and the faults in the second. A "splice" consists of the reef, which when followed either to the north or the south gradually thins out, until it becomes a mere thread of quartz, and then completely dies out. If working northward, the miner cross-cuts to the west and begins to feel for the reef again. A thread of quartz is picked up, which, if followed, often gradually thickens into the reef and forms another splice. Fault planes do not as a rule exist between the splices. The strike of the faults is generally north-west and south-east, with the down-throw side (if the faults traced be normal) sometimes to the north-east and sometimes to the south-west, the latter oftener. With regard to the splices, we have instead of one continuous fissure, which forms the lode channel, a series of small,

independent fissures, each one (when followed to the north) more to the west than the preceding one. In these quartz has been deposited. The faults have moved the reef, and are therefore clearly subsequent to it, and consequently to the formation of the splices. These are the main structural points of interest in the mine.

(c) *Dykes.*

The two dykes east of Warrandyte have already been described. There are small irregular auriferous quartz veins in the rock, which at the surface is now decomposed to a clay. These quartz veins have evidently filled the cracks formed in the dyke rock on cooling, and are therefore subsequent to the intrusion of the dykes. The latter have been worked to shallow depths, and the results are given in the mining history of the field.

(d) *The Cause of the Horizontal Limitation of the Field.*

The Warrandyte goldfield occupies very little area. Few reefs cross the Yarra, and the latter may be regarded, roughly speaking, as the northern boundary of the field. On the west and south, Anderson's Creek (with some few exceptions a little to the south) is the boundary, whilst on the east, Parson's Gully and a line drawn to the east of the Caledonia Mine, form the remaining boundary. This peculiar limitation therefore calls for explanation.

The question involves the consideration of the relation of the reefs to the folds of the rocks, and the more westerly of the two dykes to the east of Warrandyte. As has been seen, the reefs appear to be connected with the folds, and to bear a distinct relation in regard to their horizontal lengths to the lengths of the folds. The dyke on the other hand has a direction and a position that suggest an influence on the lengths of the reefs. The view held by the local miners is that the dyke has in some way cut the reefs off. This could happen in two ways—viz., faulting and intrusion of the dyke subsequent to the formation of the reefs; and the formation of the dyke prior to the reefs, the former acting as a barrier to the latter.

Whether the dyke occupies a great fault, or merely a fracture, or a fault with little displacement, is an important question to decide. There is little evidence of a great fault.

In places the western wall appears somewhat smooth, but no striations or slickensides have been noticed. The rocks on opposite sides are slightly different lithologically, but a little slip could produce this. The dip of the strata on the western wall is not easily determined, but it appears to be the same as that on the eastern wall—i.e., to the east. The dyke meets the Main South Anticline near its northern termination, and this is rather peculiar, but on the other hand, if the dyke proceeds north-westerly to Kangaroo Ground, as shown by Mr. Whitelaw, it does not disturb the Main North Anticline, and the syncline to the east.

This fact and the structure generally support the contention as to the non-importance of the dyke structurally. The minor folds certainly tend towards a common point, and do not run parallel to one another towards the dyke. The strike of the eastern limb of the Warrandyte Anticline swings round from north-east to north-west, just as would be expected if the pressure on the eastern limb were very great at one point, and it was not much relieved by crumpling. In the least disturbed part of the eastern limb—i.e., south of Warrandyte—the dips regularly continue from west to east across the line of dyke. No appearance of faulting is here. As already remarked when discussing the quartz reefs, there seems to be a direct connection between the lengths of the minor folds and the reef occurrences.

On the whole therefore I think that the dyke in either of the two possibilities above suggested has had no influence in the general geological structure of the country, and hence none on the reefs so far as their distribution is concerned. The minor folds, with fractures as the result of great pressure, offer a solution of the distribution of the reefs. In no other parts of the area have well defined and numerous reefs been found, and it is only at Warrandyte that such intense contortion has taken place. It is interesting to note that where some anticlinal folds are pressed closely together, as at Ringwood and Templestowe, isolated reefs occur.

(e) *Age of the Reefs and Dykes.*

Little can be said under this head. They are both of course post-silurian, but which were formed first, or whether they were contemporaneous, cannot at present be stated. Auriferous quartz appears to have been introduced into the dykestone, subsequent to cooling, on its joint planes, but this does not relatively fix the age of the reefs, as the cross-courses and bedded veins show that the silica has been introduced at different periods. The question must for the present remain open.

(f) *Mode of Occurrence of Gold.*

As far as can be learnt, the gold is almost wholly confined to the main reefs, and in these is fairly evenly distributed when occurring in payable quantities. At the Victory mine it is said to have occurred in a wedge-shaped almost vertical shoot, and in several smaller shoots. At the Caledonia, a very rich yield was obtained from between the surface and the third level (about 300 feet). It appears to have been bounded on the bottom by a bedded vein parallel to the pitch of the rocks. Below this vein, which evidently fills an old fault plane, the gold practically ceased.

Along the top of Fourth Hill, no well-defined reef has been worked. In the coarse sandstones that outcrop on the crest of the hill, and form the cap of the Main South Anticline, much quartz has been deposited, but was evidently not very auriferous, as the sandstones have been very little worked. Most of the workings are in the eastern limb of the anticline near its axis, in shales, and the quartz veins appear disconnected. The distribution of the veins and the mode of occurrence of gold, according to old resident miners, who have personally worked at Fourth Hill, were as follows:—"Droppers" (being quartz veins two inches or three inches thick, and underlying to the west, not far from the vertical) on being followed down, would meet a bedded vein underlying to the east (the dip of the strata). At the junction, the quartz would thicken and gold would be found. The bedded vein would then be traced on the underlie for varying distances from 10 feet to 30 feet, after which it ceased to be payable, and the gold apparently gave

out. Sinking would then proceed down the "dropper" until the next bedded vein was met, when this in turn would be followed until it ceased to be payable. The bedded veins were generally about one inch thick. The "droppers" passed through the bedded veins without any faulting. The "droppers" so far as seen were not connected with any well-defined reef. This mode of occurrence was seldom found on Third Hill, and not elsewhere on the field. We have here apparently an example of the principle of intersection with deposit of gold.

Some of the conglomerate bands in the silurian have been prospected for gold, and some workings occur at Fifth Hill. Some of the miners with South African experience thought there was a similarity to the banket beds of South Africa. The writer was informed that a few ounces of gold were found in one of the conglomerates, but whether between the pebbles (as in our ordinary gold-bearing gravels), or in a reef that might pass through the conglomerate (as some do), was not clear. Evidently, however, they have not proved payable, although the determination of the point would be a matter of scientific interest.

(g) *Mining History.*

The account now given of the history of the Warrandyte goldfield is based upon the official reports of the Mines Department from May, 1859, to June of the present year. So far as the writer is aware, no official publications appeared before 1859. Those that have been used are referred to in a general way in the list of literature at the end of this paper (14). The yields stated by Mr. Forbes in his report already referred to have not been used or verified, as insufficient details are given.

According to Westgarth (15, p. 125), Anderson's Creek, Warrandyte, was the first place where gold was discovered in Victoria. Whether it was actually the first is not quite clear, but there is no doubt that it was one of the very earliest. The date is stated to be July, 1851, and £1000 was paid by the Government to the discoverers, L. J. Michel and party (16).

From 1851 to 1859, no official records are available, and therefore the portion of the mining history covered by this period cannot be touched upon.

It will be as well to distinguish between the quartz and alluvial mining. The quartz mining will be treated first.

Once the discovery of gold was made the reefs of the district were no doubt rapidly located, and any rich pockets of gold quickly obtained. After the first rush the miners must have sought the fields which have since risen to such importance—Ballarat, Bendigo, etc.—for in 1860 the Mining Surveyor refers to the numerous abandoned reefs, and the few quartz miners on the field. He considers one great drawback to the district is the want of crushing machinery, and the high price the miners have to pay for having their quartz treated, the price rising as high as £4 per ton. Several attempts were made to remedy this by the introduction of various crushing machines to the district, but none seemed to work effectively until the construction in 1868 of machinery worked by water power on the Yarra. The rates for crushing and cartage were also reduced.

A distinct impetus was in this year given to quartz mining, apparently owing to the facilities mentioned, although the crushing machinery was not very satisfactory. The impetus is shown by the yields between 1861 and 1870. From October, 1861, to June, 1868, 138 tons of quartz were crushed, yielding 153 oz. 0 dwt. 13 grs. of gold. From the latter date to the end of 1870, 725 tons of quartz, yielding 930 oz. 9 dwt. 13 grs., were crushed. There may be some exaggeration here, due perhaps to the returns in the early part of the decade not being so complete as in the later part. Making all reasonable allowance however for this possibility, the great difference between the periods mentioned remains.

During the next decade, the yield continued fairly steady. Few new reefs appear to have been discovered, the old reefs being worked by small parties with varying success. No very rich returns were obtained, those from the Pigtail Reef being the best. This reef and the Yarra Tunnel Reef were the most successful. These, together with the so-called diorite dykes, which were discovered in this decade, will be discussed separately.

During the next decade there was a serious decline. The Yarra Tunnelling Reef was resuscitated, and yielded fairly well,

but the general returns were small. This declension was probably in part due to the extraordinary wave of prosperity throughout Victoria, which culminated in the great land boom of 1888, and which drew people from a mining field such as Warrandyte.

From 1891 to 1900, the yield rose again considerably and almost equalled that of the period 1871-1880. Almost half of the yield came from the Victory Mine from three years' working.

From 1901 to the middle of 1910, the amount of gold obtained was quadruple that of the preceding decade. The yield was almost wholly due to the Caledonia Mine.

The following table shows the yield from quartz, in decades from October, 1861, to the middle of 1910, together with the tonnage, average yields and values, taken from the official records.[1]

Period.	Tons	cwt.	Total yield. oz.	dwt.	grs.	Average per ton oz.	dwt.	grs.	Value.	Per oz.
1861–1870 -	863		1083	10	2	1	5	2	£4144/7/9	£3/16/6
1871–1880 -	2136		3668	16	3	1	14	8	14583/6/0	3/19/6
1881–1890 -	917		1123	11	2	1	4	12	4423/15/7	3/18/9
1891–1900 -	3731	14	3263	8	10		17	11	13054/0/0	4/0/0
1901–1910 -	13397		13135	15	0		19	14	52543/0/0	4/0/0
Totals - -	21044	14	22275	0	17	1	1	4	£88748/9/4	

These figures do not include the yields from mullock, quartz, tailings, pyrites, etc., but as some of the returns from these sources include alluvial results, no exact figures can be given. It is quite safe to state however, that the whole would not exceed £1000 in value.

The results of the working of the two dykes are also not included. As shown below, the value of the gold obtained from them is £7066.

Thus according to the official figures the total amount of gold won from quartz and the dykes during the past fifty years amounts to less than £100,000, of which, in round figures,

1 The fractions of grains have been omitted from the average yields, and the values have been calculated to the nearest ¼ oz. These returns include those from the reefs (Loyal Liberal, Growler's and Pride of the Morning) a little north of Warrandyte, which are associated with the Main North Anticline.

£51,000 was obtained from one mine, the Caledonia, in the five years, 1905-1909.

In connection with these figures it must be borne in mind that they represent the minimum gold obtained. Some yields may have been omitted from the tables owing to the difficulty of identifying the locality of various reefs. It is impossible for the officials to collect the results of all workings, and this applies more particularly perhaps to the earlier years. At the same time it is but fair to remark that the system of obtaining the returns has been in force for 50 years, and has been carried out by able officers. The results may therefore be regarded as substantially correct.

It is to be regretted that the statistics for the first ten years of the field are not available, as they no doubt would have added a fair amount to the total gold won.

The writer does not propose to attempt to deal with the history of even all the more important reefs or lines of working. Even if desired, this task is made quite impossible by the multiplicity of names of reefs and parties, from which the places where the gold was obtained cannot be determined. A few remarks however may be made about those reefs or workings which have yielded the best results or been developed the most. These are the Yarra Tunnel, Pigtail, Victory and Caledonia Reefs, and the two dykes already noticed.

The Yarra Tunnel Reef is apparently the continuation south of the Caledonia Reef crossing the Yarra, north of the island. If this be correct it is therefore on the line of the Caledonia Syncline.

In 1870 it is referred to as being worked under the bed of the Yarra, and the workings were continued till 1874 by various parties. It was then abandoned, but rediscovered in 1884, and traced northerly 900 feet. Its width is stated to be from 18 inches to 12 inches. Development proceeded, and profitable yields were obtained until 1888, when the mine was abandoned in consequence of the reef bifurcating, leaving a very thin vein which yielded poorly. The workings were to a depth of 150 feet below the river, and further shaft sinking was done, but to what depth is not stated. From 1869 to 1874 and from 1884 to 1888 311 tons of quartz were crushed, yielding 628 oz. 9

dwt. 16 grs., averaging 2 oz. and 9 grs. per ton, and valued at £2486. Almost all the gold was obtained within 100 feet of the surface. No further record of fresh workings exists.

The Pigtail Reef, which lately was worked by the Caledonia Consols Company, is first noticed in 1874, and in 1875 some rich yields are quoted—387 tons giving 1409 oz. 7 dwt., and averaging 3 oz. 12 dwt. and 19 grs. per ton. This was obtained at a depth of 80 feet and above that level. Subsequent yields came mainly from greater depths (up to 145 feet), and were not nearly so rich as those quoted. The reef was worked fairly continuously by various parties until 1881, when a slide was encountered at a depth of 170 feet. Two or three fitful attempts were made at re-working the reef, but practically nothing was done until the Caledonia Consols Company was formed. In 1905 this Company sank a new shaft to a greater depth than the old workings, and erected new machinery, including a battery. The lode was met, but was not payable. A second shaft was sunk, but the results were disappointing, and the enterprise was abandoned. From 1875 to 1881 939 tons were crushed, yielding 1882 oz. 4 dwt. 2 grs., averaging 2 oz. 0 dwt. 2 grs. per ton, and valued at £7481. Since 1881 only the sum of £614 10s. from 301 tons has been obtained from the reef, making a total recorded from this reef of £8095 10s.

The Victory Reef is on the line of the Main South Anticline, and has been worked chiefly under Third Hill. The gold yields under this name commence in September, 1896, and continue fairly regularly to September, 1899, during which period 1570 ozs. from 1038 tons, valued at £6280, were obtained. From 1899 the mine appears to have been intermittently worked until it was abandoned in 1904. Only an additional 47 ozs. are accounted for, making a total of 1617 ozs. 2 dwt. 4 grs. from 1090 tons, with a yield of 1 oz. 9 dwt. 16 grs. per ton, and valued at £6468. The yields in the early part of the period came from 100 to 150 feet in depth. The later returns do not state the depth. I was informed the shaft had been sunk about 220 feet, and a winze another 50 feet. I have no knowledge as to whether any dividends were ever paid. The mine was resuscitated as a result of the Caledonia boom under the name of the New Victory, but practically no work was done.

The Caledonia Mine (the actual name of the Company was the Caledonia Gold Mines) is situated towards the northern end of the Caledonia Syncline near the Yarra. It was formerly known as the Newhaven. The mine was worked from 1905 to 1909. According to the Annual Report of the Mines Department for 1909, the mine yielded 12,772 ozs. from 12,653 tons, the called-up capital was £8250, and the total dividends amounted to £12,583 15s. These figures determine the average per ton at 1 oz. and 4 grs., and the total value of the gold obtained at £51,088. Most of this gold was obtained between the surface and 300 feet. The shaft was sunk to 600 feet, but the stone did not prove payable, and the mine was shut down. The Caledonia yields are the one really bright feature of the Warrandyte goldfield.

The two dykes to the east of the township were discovered in 1877. The eastern one has been little worked. The rock has been decomposed to a clay, which is intersected with thin, irregular quartz veins, and contains pseudomorphs of iron oxide after pyrites. The whole of the material went to the battery. These dykes have been worked to a depth of 200 feet. They were worked continuously by various parties from 1877 to 1886. They were then discontinued until 1893, when a little work was done, and the same occurred again in 1898 and 1909, apparently without payable results. They have therefore practically not been worked since 1886. From 1877 to 1886, 22,114½ tons were crushed, yielding 1762 ozs. 6 dwt. 22 grs., giving an average per ton of 1 dwt. 14 grs., and a total value of £6959 18s. The total yield to 1909 is in round numbers valued at £7000. Considering the length of the period during which these dykes were worked, the inference is that the yield was sufficient to be payable. From the detailed figures, the dykes show a decrease in value at depth.

Some isolated yields from the quartz reefs of the field generally may be quoted:—

In Quarter ending	Locality	Quartz tons	Total Yield oz.dwt.grs.	Av. Yield oz. dwt. grs.	Depth obtained ft.
30/6/69	—Fourth Hill - - -	3½	28 2 2	8 0 14.28	140
30/9/73	—Industrial - - -	5	42 18 0	8 11 14.40	70
31/3/74	—Marble Hall - - -	3½	25 5 0	7 4 6.85	70
30/6/75	—Pigtail - - - -	141	448 17 0	3 3 16	30
31/12/75	—Pigtail - - - -	166	800 0 0	4 16 9.25	80
31/12/80	—Messrs. Sloan & Party (Fourth Hill) -	11	249 12 0	22 13 19.64	30-35
31/3/81	—Messrs. Sloan & Party (Fourth Hill) -	4	29 10 0	7 7 12	35
31/3/83	—Young Colonial - -	3	28 18 0	9 12 6	40
31/3/85	—Yarra Tunnelling - -	28	121 4 20	4 6 14.43	80
30/6/92	—Black Swan - - -	22	106 13 0	4 12 9.4	40
30/6/95	—Messrs. Blair Bros. - -	2½	37 2 0	14 16 19.2	—
31/3/96	—Messrs. Dixon & Holloway	3	27 14 1	9 4 16	60
31/3/96	—Messrs. H. Squires & Party	3	88 0 0	29 6 16	—
30/9/96	—Victory - - - -	4	29 12 0	7 8 0	100

The results from alluvial mining cannot be given. No regular returns can be obtained. Instances are recorded of various rich finds, but nothing definite can be stated as to the workings as a whole.

From the general reports of the Mining Surveyors and Registrars, the gullies and creeks tributary to the Yarra at Warrandyte have not been very profitable. The best returns have been from the bed of the Yarra itself. The river was in the early days dammed and paddocked so as to reach the gold, and the results in general are stated to have been satisfactory. In later years further efforts were made, but without success. The bulk of the gold had apparently been obtained by the earlier miners.

Two undertakings, on account of their magnitude, deserve to be mentioned. One is the cut through the river at the bend known as Thomson's Bend, near Parson's Gully, by which an island was formed, and the other the tunnel through the rocks at Pound Bend, connecting the river at two points. The object in each case was to divert the river from the bend, and obtain the gold from the river bed.

The cut at Thomson's Bend was begun in 1859, and completed in 1860. The river was diverted through the new cut, and the old bed laid dry. Difficulties were encountered by the

river breaking through the dam. No details of the results are given, but as the enterprise soon ceases to be mentioned by the Mining Surveyor it was presumably a failure.

The tunnel was successfully made at the Pound Bend in 1870, and the river diverted through it. Trouble arose through the river finding a new course. This was repaired, but as no definite results are stated, and mention of the scheme soon ceases, this must also be regarded as a failure, although gold in patches is stated to have been distributed all round the bend. Each undertaking must have been expensive.

(h) *Possibilities of Further Development of Quartz Mining.*

There are two phases to this question. First, whether any horizontal extension of the field is likely, and secondly, the prospects of payable stone at greater depths than hitherto worked at the present-known reefs.

The first aspect must be answered in the negative. The geological structure of the field indicates a close connection between the highly folded area and the quartz reefs. This area is limited to Warrandyte, so that beyond it, the fractures necessary for the formation of the reefs would not be expected, and, so far as observation goes, this is correct.

Mr. Moon, on the Quarter Sheet already cited, and Mr. Whitelaw on his map of part of Nillumbik Parish, show a moderate number of quartz reefs outside the Warrandyte area. The writer has not seen all these reefs, but those inspected, so far as could be seen, are thin, irregular, and generally in localities where the geological structure of the country does not favour any system of fractures. Some of these reefs have been slightly opened up, but the prospects were evidently unfavourable. The development of some of them may also have been hindered by being on private property, and some may exist that if worked would be payable. Gold has been found in gullies on the northern side of the river at Warrandyte. This may have come from isolated reefs, or the dykes, or from the gravels under the basalt at Kangaroo Ground, or from all three.

Allowing, however, for these possibilities, the structure of the country surrounding Warrandyte does not support any hope of a substantial extension of the present, or of the discovery of a new goldfield.

The second phase of the question is more difficult to deal with. Extensive shallow workings exist along the line of the Main South Anticline from the Great Southern Reef to the Yarra, but their history is not fully known. The same may be said of most of the other workings on the field. Throughout the official records there is scarcely a hint as to the mode of occurrence of gold, nor any light as to its origin and distribution. At the time of the writer's visit to Warrandyte, only one mine—the Caledonia—was working, and from that no gold was being obtained. Thus there is little to help the question.

Most of the workings show that further effort was abandoned when the level of ground-water was reached. The depth at which the gold was obtained is recorded in the official returns to 1898 fairly completely, and these show conclusively that the great bulk of the gold was found at and above 150 feet below the surface, and most of this within 100 feet from the surface.

Most of the gold therefore up to 1898 was found within the zone of oxidation or vadose zone. Since 1898 the Caledonia and the Victory are practically the only mines that have been working. The Victory went below the water-line, and some of its gold may have come from there. At the Caledonia the level of ground-water is near the surface, and the bulk of the gold came from below that level—i.e., from the (probably enriched) sulphide zone.

It is important to determine for the point under discussion whether the reefs are likely to prove permanent in depth and whether secondary enrichment has taken place. As regards the former, although the reefs are thin, there is ground for believing that they continue in depth. The minor folds are clearly defined, and there is no reason to doubt that the fractures which accompany them descend some distance. At the 600 feet level of the Caledonia the reef became very thin, but there was a roll to the east, which would probably account for its pinching in. I was told that it became a strong reef again below this level, when it had its normal underlie again.

The Yarra Tunnel Reef was abandoned on account of its bifurcation, but this does not necessarily prove that it may have met and thickened again lower down.

Secondary enrichment has probably taken place in the reefs here, both in the vadose zone generally and in the sulphide zone at the Caledonia. The geological structure shows the vast amount of silurian strata removed from the surface of the ground at Warrandyte. The reefs must have extended upwards into these rocks, and in the denudation of the latter, the former would be removed, and if gold-bearing, would tend to enrich the undenuded parts of the reefs. There appears to be no doubt, from the general returns, that near the surface the reefs and also the dykes are richer than the lower portions worked, both in the sulphide zone of the Caledonia, and the vadose zone generally.

So far as can be determined, therefore, the reefs may not maintain their yield at depth, but as the sulphide zone below the oxidation zone is often enriched at or a little below the latter, it is possible that some reefs may have benefited in this way. Apparently the only reefs given anything of a trial in this direction are the Consols and the Victory, and they have not proved payable, so that experience gives no support to the idea. The Caledonia cannot be taken as a fair test of the enrichment of the sulphide zone, as there appears to be so little of the oxidised zone above the former to absorb the gold.

Again, one of the dykes previously referred to crosses the Yarra close to the Caledonia. It is possible that the gold in the Caledonia may have been leached out from this dyke. The other reefs are some distance from the dyke, and may, therefore, not have benefited by it. Considering all the evidence, the probabilities are, therefore, against the maintenance of the yields in depth, but this does not exclude the possibility of shoots of gold in some reefs which, if worked with strict economy and care, may be found payable at greater depths than at present worked.

Summary.

The paper deals with the silurian rocks of a wide area of country in the basin of the Yarra.

The rocks are shown to consist chiefly of shales and sandstones, with a series of fossiliferous grits and conglomerates at Warrandyte.

The geological structure of the silurian consists principally of a great arch or geanticline at Warrandyte, on the top of which are a series of minor folds, with which are associated the conglomerates and grits, and a series of auriferous quartz reefs. This fold is known as the Warrandyte Anticline. It extends from Tunstall to Watson's Creek, and its axial line is broken at Warrandyte. To the south and north of Warrandyte it breaks into more normal folds, which are described. To the west of the Warrandyte Anticline is the Bulleen Syncline, a great feature traced some distance north and south. Farther west is the Templestowe Anticline. Various dykes are associated with the rocks.

The evidence of faults and peculiarities of joints in the silurian is discussed, including the smooth fracture of conglomerate pebbles.

The conditions of sedimentation in the silurian are referred to.

The age of the silurian rocks cannot be settled until the fossils are examined. On field evidence alone, the oldest beds are at Warrandyte, and the youngest at the Bulleen Syncline, and to the north of Croydon.

The thickness of the western leg of the Warrandyte Anticline is estimated at between 12,000 and 13,000 feet, and that of the eastern at between 14,000 and 15,000 feet, while the vertical height of the silurian removed from above the Warrandyte Anticline is probably over 12,000 feet.

The rocks from which the silurian conglomerates were derived are shown to be altered and unaltered sedimentary rocks.

The Warrandyte goldfield is shown to be due to a series of minor folds on the top of the Warrandyte Anticline, which have fractured and so admitted the silica and gold. The distribution of the quartz reefs is noted, and their relation to the folds and the dykes to the east is discussed. The conclusion is drawn

that the horizontal limitation of the goldfield is due to the limitation of the minor folds (most of which rapidly merge into one fold).

The mode of occurrence of gold, a general account of the mining history, and the possibilities of further development of quartz mining are referred to.

A list of the literature referred to is given.

In conclusion, I wish to express my thanks to Prof. Skeats for advice and criticism in connection with my work. I have also to thank the respective permanent heads of the Lands and Mines Departments for the use of maps, and for permission to inspect some unpublished returns of gold, the access to which was facilitated by Mr. D. J. Mahony, of the Geological Branch, and Mr. D. Wallace, of the Statistical Branch, to both of whom my thanks are due. My brother, Mr. C. A. Jutson, was also good enough to compile the table of gold returns for the various decades, the data for which I am, however, alone responsible. I have also to thank Messrs. F. Trezise, J. Sloan, H. and F. Squires, of Warrandyte, for information relating to the mines there.

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EXPLANATION OF PLATES.

Plate XCI.

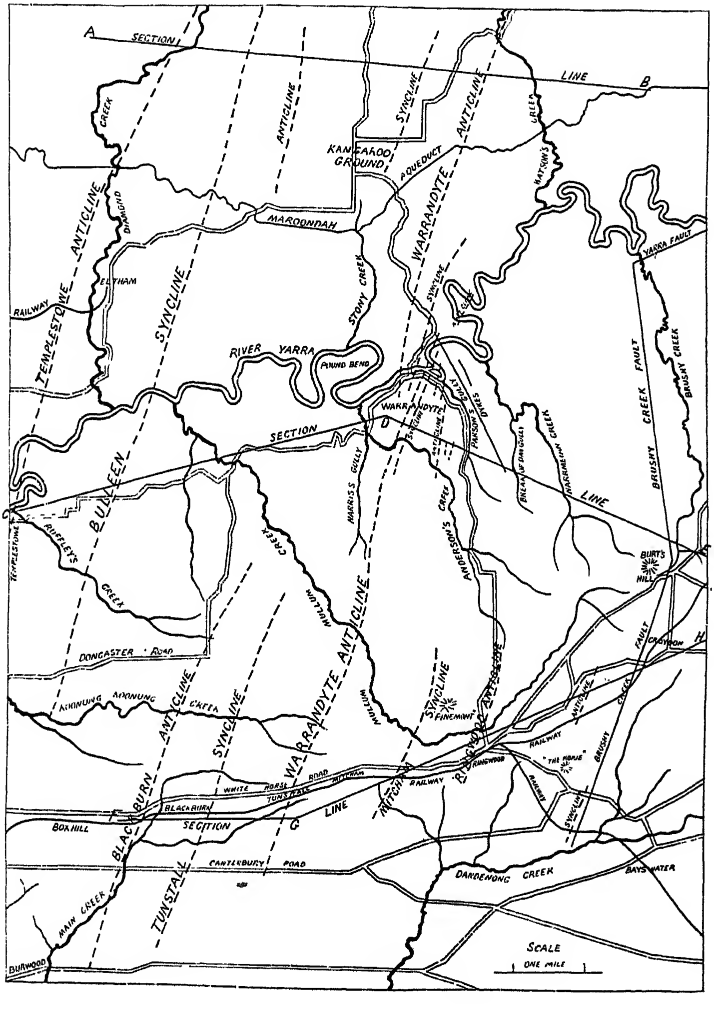
Sketch map of the whole or parts of the Parishes of Nillumbik, Sutton, Warrandyte, Ringwood, Bulleen and Nunawading, compiled chiefly from the parish maps. The basalt at Kangaroo Ground is not shown, as the map is intended only to illustrate the general geological structure of the silurian rocks of the district. The results only of the survey are indicated, as the scale of the map precludes any adequate detail being set out.

Plate XCII.

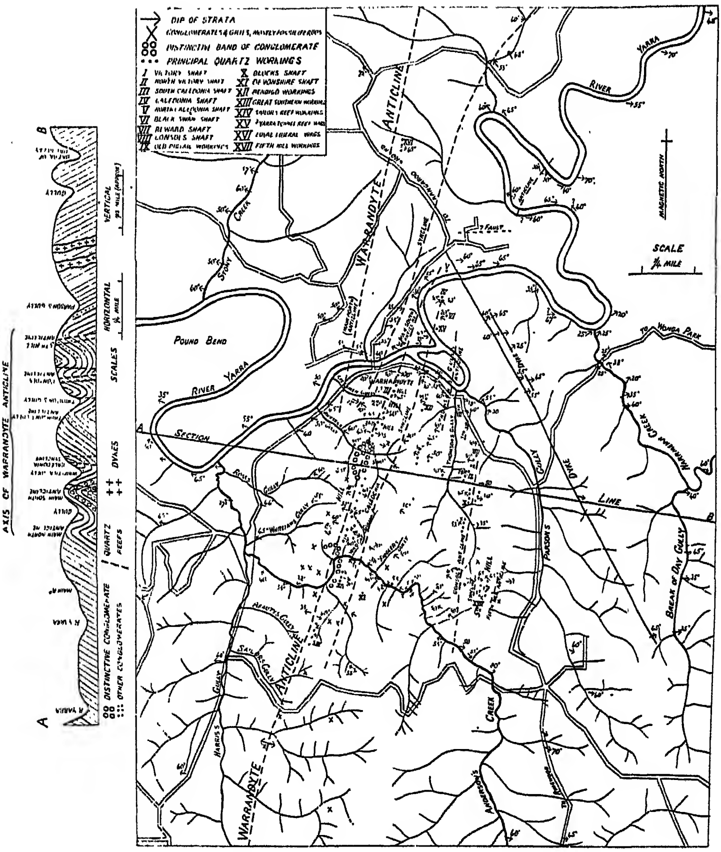
Enlarged map of, and section across, the Warrandyte goldfield. All available details are not shown.

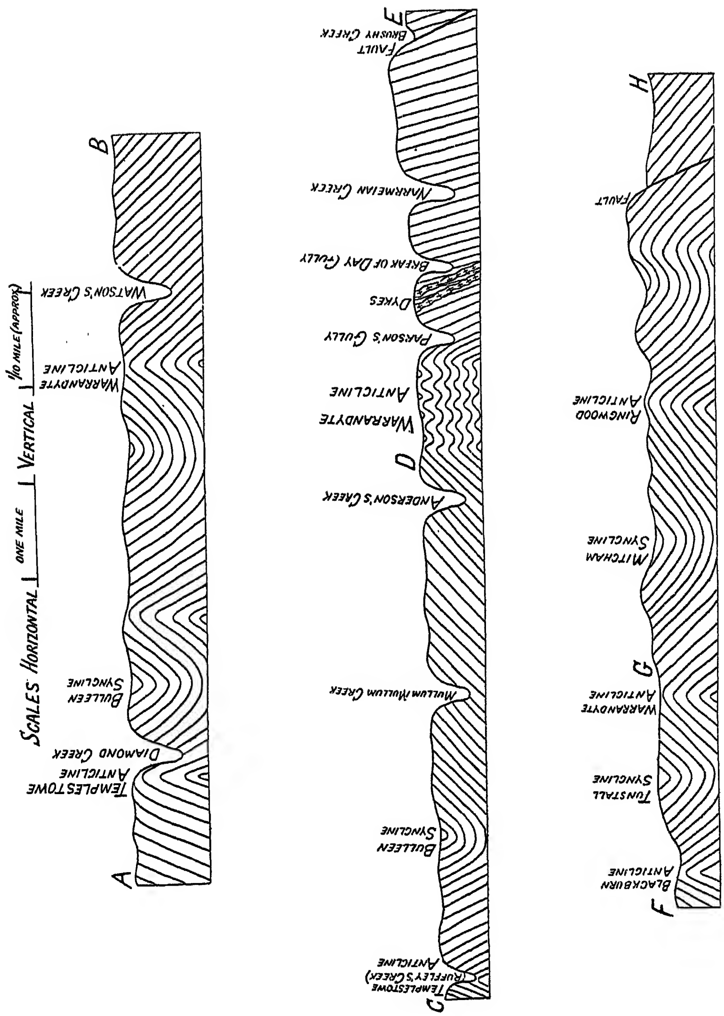
Plate XCIII.

Sections illustrating the general geological structure of the country comprised in Plate XCI. In these sections, and in that on the Warrandyte goldfield map, the datum line is sea-level.



A SECTION LINE B
ANTICLINE
SYNCLINE
ANTICLINE
CREEK
WATSON'S CREEK
KANGAROO GROUND
AQUEDUCT
WARRANDYTE
TEMPLESTOWE ANTICLINE
DIAMOND
MAROONDAH
SYNCLINE
ELTHAM
RAILWAY
STONY CREEK
YARRA FAULT
RIVER YARRA
POUND BEND
WARRANDYTE
D SECTION LINE
BULLEEN
HARRISS GULLY
ANDERSON'S CREEK
PANTON'S GULLY
DYKES
BREAK OF DAY GULLY
NARRMEIMN CREEK
BRUSHY CREEK FAULT
BRUSHY CREEK
BURT'S HILL
TEMPLESTOWE
RUFFLEY'S CREEK
MULLUM CREEK
WARRANDYTE ANTICLINE
DONCASTER ROAD
CROYDON
H
KOONUNG KOONUNG CREEK
ANTICLINE
SYNCLINE
FINEMINT
RINGWOOD ANTICLINE
FAULT
BLACKBURN ANTICLINE
MITCHAM
RAILWAY
RINGWOOD
"THE MOUNT"
BRUSHY
WHITE HORSE ROAD
TUNSTALLS
BLACKBURN
F
G LINE
BOX HILL
SECTION
SYNCLINE
CANTERBURY ROAD
DANDENONG CREEK
BAYSWATER
TUNSTALL
MAIN CREEK
SCALE
ONE MILE
BURWOOD


DIP OF STRATA
DISTINCTIVE BAND OF CONGLOMERATE
PRINCIPAL QUARTZ WORKINGS
I VICTORY SHAFT
II NORTH VICTORY SHAFT
III SOUTH CALEDONIA SHAFT
IV CALEDONIA SHAFT
V NORTH CALEDONIA SHAFT
VI BLACK SWAN SHAFT
VII REWARD SHAFT
VIII CONSOLS SHAFT
X BLUCKS SHAFT
XI DEVONSHIRE SHAFT
XII BENDIGO WORKINGS
XIII GREAT SOUTHERN WORKINGS
XVII FIFTH HILL WORKINGS
ANTICLINE
WARRANDYTE
RIVER
YARRA
POUND BEND
SECTION
LINE
DYKE
SCALE
¼ MILE
MAGNETIC NORTH
TO WONGA PARK
CREEK
BREAK OF DAY GULLY
HARRIS GULLY
SAILORS GULLY
ANDERSON'S CREEK
STONY CREEK
PARSON'S GULLY
AXIS OF WARRANDYTE ANTICLINE
SCALES
HORIZONTAL ¼ MILE
VERTICAL
QUARTZ REEFS
DYKES
DISTINCTIVE CONGLOMERATE
OTHER CONGLOMERATES
A
B



Scales Horizontal One Mile
Vertical 1/10 Mile (approx)
A
B
Watson's Creek
Warrandyte Anticline
Bulleen Syncline
Diamond Creek
Templestowe Anticline
C
D
E
Brushy Creek
Fault
Narremian Creek
Break of Day Gully
Dykes
Parson's Gully
Warrandyte Anticline
Anderson's Creek
Mullum Mullum Creek
Bulleen Syncline
Templestowe (Ruffley's Creek) Anticline
F
G
H
Fault
Ringwood Anticline
Mitcham Syncline
Warrandyte Anticline
Tunstall Syncline
Blackburn Anticline

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Art. XXXVII.—*Flotation of Minerals.*

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Introduction.

The various flotation concentration processes have in the last few years attained much prominence in Australia, and particularly at Broken Hill, and promise to displace many of the ordinary gravity processes in other parts. Very little literature has appeared on this subject, and, with the exception of a few scientific papers, most of it has been descriptive of the working of various processes, and not on the investigation of the general underlying principles. The two usual explanations given as to the cause of the flotation of minerals and metals in various solutions are:—

(1) That it is due to certain surface tension phenomena.
(2) That it is due to the attachment of certain gases to the minerals which lift the particles to the surface.

In a paper by J. Swinburne and G. Rudorf,[1] the authors explain why the sulphides rise in preference to the silicates, etc., and why the bubbles remain attached to the sulphides, as due to the combined effects of surface-tension, cohesion and adhesion. They consider that the rise of temperature to near boiling point is necessary for flotation for the same reason.

Behaviour of Minerals and Metals in Water.

The object of the writer's work was to investigate the attachment of gases to the different minerals and metals, and incidentally to study the adhesion, or wetting of different minerals and metals, and their subsequent flotation.

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1 The Physics of Ore Flotation. Chemical News, 29th December, 1905.

Cold water.—Minerals and other substances differ in their inclination or otherwise to become wetted by water or by other liquids. Many minerals when dropped carefully on to the surface of water remain on it and do not sink. Some at once sink to the bottom. Particles of considerable size may be floated in this manner, and sometimes considerable force is required to make them sink. Some minerals, when ground so as to pass a 30 mesh sieve, form a film on the surface of the water, and this film will support a considerable weight. A certain sample of zinc blende concentrates could be heaped up in this manner to a depth of $\frac{1}{4}$ inch on the surface of water in a 50 c.c. cylindrical beaker. The weight of material was 15 gms., and the top portion was quite dry. The following is a list of the minerals tried that would float on the surface of water:—Galena, zinc blende, sulphur, azurite, malachite, rhodonite, garnet, calcite, mica, telluride of gold, pyrite, pyrrhotite, wolfram, cassiterite, serpentine. And besides this all the metals in the form of foil would easily float. Some samples of quartz will float and others will not. Particles of glass and turquoise would not float.

The weight of each particle on the surface causes a distinct depression or sag round itself, and the apparent attraction of one particle for another is probably due to the depressed surface caused by this sagging. If some liquids (such as alcohol in the form of a drop on a glass rod) are brought near the particles floating on the surface, the particles are repelled from the rod. If alcohol is added to the water the particles become wetted and sink. Caustic soda acts similarly. This is apparently a surface tension phenomenon. In the case of alcohol on the glass rod, the vapour of the alcohol mixing with the water decreases the surface tension and increases the adhesion of the water for the mineral. The water wets the particle at a higher level on the side nearest the glass rod; an inclined plane is formed on the side furthest from the rod, and the particle is apparently repelled. Water has the greatest surface tension of any liquid under ordinary atmospheric conditions except mercury, and thus, if another liquid is added to it, the surface tension is decreased. If the minerals in the above list have been previously wetted they will not float on the surface until they are

dried or partially dried. If some ground mineral is wetted and covered with water, and then is exposed to the air by causing the water to run to one side of the containing vessel and the water is then brought carefully back, some of the mineral will be seen to float on the surface of the water. This form of flotation takes place to a greater or lesser extent with most minerals, and is apparently a different phenomenon from the simple floating of particles by dropping them on the surface. In the latter case there is an almost continuous film of air or gas surrounding the under side of the mineral, and by far the greater portion of it is projecting out of the surface of the water. That there is not a continuous film, and that the particle is partly wetted can be shown by floating some magnetic substance, as pyrrhotite, or a piece of iron wire, and attracting it with a magnet, when the surface of the water will be seen to have been dragged up with the mineral or wire. When the substance is finally lifted out of the water, water is carried up on to the magnet. In the case of the wetted mineral being floated by being brought into contact with the air, the particles will be seen to be almost entirely submerged, only a portion like a pin's point being above the surface, and, although a distinct depression of the surface is caused, it is not so apparent as in the other case.

When the minerals are made to sink they apparently carry a bubble of some gas down with them. This bubble can be seen as a rule on most particles. When the finer-grained material is heaped up on the surface (as in the case of the zinc concentrates referred to) till the weight is too great, the whole mass causes the surface of the water to sag, and finally to break through, and carries a large amount of air down with it, the inside of the envelope being quite dry.

Hot water.—In hot water the behaviour of the minerals and metals is different. Most of them will float but for a few seconds only, becoming wetted and sinking, usually a bubble of gas leaving each particle as it sinks. The fine grained material can be heaped up similarly, as with cold water, a large number of bubbles being observed on the under surface of the mass.

Under the surface of water.

When the minerals are submerged in water and the water is heated, many of them will float either wholly or partially. Sulphur, crystalline azurite and malachite, some galenas, some blendes, some chalcopyrites and stibnites, and some of the metals, copper being the most persistent, will float in water on heating. A sample of zinc concentrates from the Potter process (floated with H_2SO_4) floated when heated in water, and when boiled the "scum" continued indefinitely. If boiled violently and continuously, the concentrates will sink, but if allowed to cool will again float on heating. This was repeated twelve times, and would apparently continue indefinitely, if after each time the water was allowed to cool for some time. Air will get into boiling water either being dissolved or being carried down mechanically as bubbles, as the following will show. A large beaker of distilled water was boiled continuously for two hours. An inverted funnel was then placed in the beaker and an inverted burette filled with the boiled water was placed with the wide end fitting over the stem of the funnel. Air was then slowly collected in the burette by the bubbles coming under the funnel and displacing some of the water in the burette. The funnel was arranged so that it did not rest on the bottom of the beaker, but allowed the water to circulate under it. In some cases the minerals appear to evolve a gas, and usually the water begins to boil and water vapour forms first on the minerals, or substances introduced into it, the latter giving a starting point apparently preferable to the sides of the containing beaker.

A sample of zinc concentrates under water was heated in a 10 c.c. graduated pipette and the expansion observed. These concentrates were from a Potter (acid) float, washed and dried, and then introduced into the pipette, which was immersed in a large beaker of water, and this water was then heated to boiling. The volume of concentrates as measured in the pipette was 2 c.c., and the surface of the water above them was 5.9 c.c. The greatest expansion noted by taking the difference in the reading of the level of the top of the water was 1.3 c.c. The expansion noted by the difference in the levels of the top of the concentrates before and after heating was 0.8 c.c. The volume

begins to increase at about 82 deg. C. up to 100 deg., the range of temperature at which flotation usually takes place. Just before the water began to boil some of the concentrates began to float and the reading could not be taken.

Behaviour under reduced pressure.

Many substances when sunk in water will rise to the surface when the pressure above the surface of the water is lowered. Among the substances tried the following floated:—All the metals in the form of foil, naphthalene, sulphur, graphite, mica, and zinc blende concentrates. Particles of galena, zinc blende, cerussite, river sand, and calcite came to the surface, but sank again. When a mixture of particles of zinc blende and river sand was put into a vacuum flask under water under reduced pressure, it was noticed that the zinc blende came up more persistently than the sand, which rose to the surface three or four times, and would not do so again. The particles of mineral are caused to float by gas bubbles attached to them carrying them up to the surface. In some cases these bubbles are strongly attached to the minerals. A burette was taken and filled with mercury to within about an inch of the top, and about 1 c.c. water was added on top of the mercury. A few particles of different minerals were dropped through the water on to the mercury, each having a bubble attached to it. A rubber cap with a clip was then put over the end of the burette and the lower end was connected up with a water pump. As the level of the mercury was lowered the bubbles increased in volume, and remained on the particles till the level of the mercury was lowered considerably. Some zinc concentrates from an acid float were immersed in water in a 10 c.c. graduated pipette, and the expansion noted when the pressure was reduced above the surface of the water. The greatest expansion noted before the mineral began to float was 0.8 c.c., the original volume being 2 c.c.

On some minerals bubbles will form, when subjected to reduced pressure, under water, but the minerals do not float, as quartz, garnet, gypsum, haematite, wolfram, cassiterite and glass. Pieces of metal in the form of foil will float even after

being repeatedly sunk. If the water is boiled free from air the metals will not float when the first bubbles attaching themselves are removed. A piece of copper foil, which was immersed in air-free water, and which would not float when the pressure was reduced, floated on the surface when brought in contact with the vapour above the surface of the water. Crystalline pieces of the following minerals under water under reduced pressure were all coated with bubbles:—Galena, zinc blende, garnet tourmaline, pyrite, gypsum, ardalusite, calcite, cerussite, and quartz. These minerals were then placed in water, boiled free from air, and again became coated with bubbles on reducing the pressure, thus showing that some gas is carried down with each mineral as it sinks. The metals had also bubbles attached to them, but in freeing these with a glass rod only a few very minute ones formed again. After the bubbles have formed on these minerals, if atmospheric pressure is restored, the bubbles become almost invisible, but form again in the same position on again lowering the pressure. Tarnished minerals form as many bubbles on their surfaces as the clean faced ones.

Behaviour of Minerals and Metals in Dilute Acid Solution.

On the surface.

Cold.—Similar to water even with strong H_2SO_4.

Hot.—None of the minerals would float when sprinkled on the surface of a hot H_2SO_4 solution even when very dilute (1 per cent.) becoming at once wetted and sinking. Copper foil will float on a hot 3 per cent. H_2SO_4 solution. The sample of zinc concentrates forms a film the thickness of one particle only, the remainder falling through the surface, but coming up again in the form of agglomerated masses.

Heated in acid solutions.—Most of the sulphides will float if heated in a weak H_2SO_4 solution. Some samples of pure galena and zinc blende would not float, but on the addition of calcite and generation of CO_2 floated. Haematite, biotite, quartz, wolfram, cassiterite, rhodonite, calcite, siderite, musco-

vite, serpentine would not float. In the case of the sulphides H_2S is given off to a greater or lesser extent in every case. A sample of copper matte would not float in acid solution. To show the amount of acid required a small test with a sample of the South Mine, Broken Hill, tailings was carried out, taking 10 gms. of the tailings, and 50 c.c. water, and adding different amounts of acid and heating to about 95 deg. C.

With a .36 per cent. H_2SO_4 solution no float took place.

With a .72 per cent. H_2SO_4 solution a small scum formed.

With a .9 per cent. H_2SO_4 solution a poor float was obtained.

With a 1.4 per cent. H_2SO_4 solution a good float was obtained. These tailings contain much calcite, and therefore use up more acid than most of the other companies' tailings.

Under reduced pressure.—The same lot of crystalline particles tried with water alone were tried under reduced pressure in an acid solution ranging from 1 up to 10 per cent. H_2SO_4. The bubbles formed as before, but were of a different nature, appearing to be larger, and coming away from the minerals more readily. Fewer bubbles were on the quartz and gypsum than on the other minerals. In an air-free, dilute H_2SO_4 solution, on fragments of the various minerals being dropped in bubbles form on their surface. In the case of quartz and rhodonite and the other silicates a few bubbles were carried down, but on shaking these off no more formed. This also was the case with copper foil. Bubbles formed on the sulphides, garnet, and tourmaline even after those first formed were detached. Some cubical fragments of galena were coated with lead chromate and sulphate respectively and immersed in an air-free acid solution, under reduced pressure. Only a very few bubbles formed on these particles. Most of the sulphides will not float in the cold with dilute acid. The zinc blende in a sample of South Mine tailings kept coming up to the surface, but fell back again. The carbonates are attacked by very dilute acid solutions under reduced pressure. It is interesting to note that siderite and magnesite are attacked by cold acid under reduced pressure.

Some Broken Hill Proprietary's zinc concentrates, washed free from soluble salts, were boiled in a 2 per cent. H_2SO_4 solution. The following metals went into solution, Fe, Al, Zn, Mn, and H_2S was given off. A sample of the working solution from this

company's process contained SiO_2 (0.112 gms. per 100 c.c.), Fe, Al, Zn, Mn, and Ca. A sample of the Central Mine's concentrates (oil and acid process) was washed with strong NaOH, and then washed till free from NaOH. The zinc blende would not then float on top of air-free water on boiling, but on making acid with H_2SO_4 a float was obtained. No float could be obtained by adding ammonium carbonate. Another sample of the Proprietary's zinc concentrates washed free from acid, and then washed with strong NaOH, and then washed free from alkali would not float on heating in tap or air free water, but floated on adding acetic or sulphuric acid.

Behaviour of Minerals and Metals with Oils, Etc.

On the surface.—None of the minerals tried would float on the surface of oleic acid (commercial), kerosene, or alcohol. Copper foil floated on oleic acid, but not so persistently on kerosene. Iron wire would not float on kerosene or oleic acid, but showed a tendency to float, not sinking immediately. Zinc blende, galena and the other minerals would not float on alcohol but did not immediately sink.

On heating.—None of the minerals floated on heating in kerosene or oleic acid.

Under reduced pressure.—None of the minerals or metals floated when immersed in oleic acid, alcohol, or kerosene under reduced pressure.

Behaviour of Oiled Minerals in Water and Acid Solutions.

Nearly all the minerals and metals will absorb oil if shaken up in water to which oil has been added. If previously oiled as with oleic acid, vaseline, or kerosene, nearly all minerals will float in water. Some float in the cold; others require heating or reduced pressure. The following float well:—Calcite, sulphur, galena, garnet, zinc blende, wolfram, cassiterite, siderite, cerussite, magnesite, azurite, malachite, rhodonite, and some quartz, and the metals in form of foil. The following give no

float, or a very poor float:—Muscovite, amorphous malachite, turquoise, gypsum, quartz and particles of slate. Calcite and muscovite if crushed together can be separated by oleic acid, the calcite floating, and the muscovite not absorbing the oil. Copper matte will give a flotation with oleic acid in H_2SO_4 solution. Whether a mineral is caused to float, or is merely collected together in a mass or in small rounded balls, or is made granular but coherent, is dependent on the quantity of oil used. A series of tests carried out showed that with an excess of oil over the mineral the latter was caused to float by being carried to the surface of the water by the lighter oil. With oil and the mineral in certain ratios as 5 gms. oil to 20 or 30 gms. of zinc blende the oil and mineral formed one globular coherent mass. By increasing the amount of mineral and keeping the same amount of oil, smaller rounded masses of oil and mineral formed which would not float until finally with a large amount of mineral (150 gms.) and 5 gms. oil a granular product was formed which would float on violent agitation, being buoyed up by attached air bubbles. On adding acid to the minerals which have absorbed oils in presence of water, most minerals other than sulphides and metals will not float on heating, the acid apparently causing them to separate from the oil. The amount of acid required to make the action selective is very small, but from the results of numerous tests it is apparent that with only minute quantites of acid the action is only partially selective. If more acid is used the freer from gangue the concentrates will be. Calcite and oleic acid will not mix in the presence of oxalic acid, although the calcite is not apparently attacked. Calcite will absorb oleic acid in the presence of acetic and lactic acids. There is no very marked difference between the behaviour of sulphur and oleic acid in an acid solution or in water. Carbon bisulphide acts similarly to an oil, and is apparently absorbed by the minerals.

Oiled Minerals under reduced pressure.

Crystalline fragments of tourmaline, garnet, zinc blende, galena, pyrite, quartz, gypsum, andalusite and calcite—were taken, two of each, one oiled with oleic acid and the other

unoiled. These were immersed in water, and the pressure reduced above the water. Bubbles immediately formed on the oiled minerals, and on further decreasing the pressure, bubbles larger and in greater number formed on the oiled than on the unoiled minerals. The nature of the bubbles on the oiled and unoiled minerals were different, those on the oiled being of an inverted watch glass shape when first formed. On adding acid (H_2SO_4) the bubbles change in character. Most of the bubbles left the unoiled quartz and gypsum, but not the other minerals. At the lower pressure CO_2 was evolved from the calcite which was not attacked at first, showing that the acid solution gets under the oil film on the mineral. With a lens minute specks could be seen on the faces of the pyrite crystal which gradually grew into larger bubbles on reducing the pressure. On restoring atmospheric pressure the bubbles became almost invisible again. The bubbles on the oiled minerals were of a more permanent character and the manner of leaving the minerals was also different. In the case of the oiled minerals the bubbles become distorted and drag away more than in the case of the unoiled minerals. On warming the solution the bubbles clung much more tenaciously to the sulphides than to the other minerals, the quartz, calcite, and gypsum being almost free from bubbles.

If a layer of oil is floated on top of water and a particle of a mineral as galena or quartz is dropped on to it, the mineral will only sink as far as the top of the water and remain there. Minerals will sink through alternate layers of different oils floating on water, and will remain floating on the top of the water. If a particle of some mineral is sunk in water and a layer of oil is floated on top of the water, and if the pressure is reduced above the surface of the oil, the mineral particle will rise as far as the surface of the water, and will not penetrate the oil layer. Three beakers were taken, each containing a saturated CO_2 solution in water. A layer of oleic acid was added to form a layer over the surface of one, kerosene in another and petrol in the third. Particles of different minerals were then dropped into the beakers, and their behaviour noted. All the minerals carried down oil with them in the form of a circular "blob." CO_2 gas immediately began

to collect under the surface of the oiled particles in the form of very small bubbles, which collected to form one large bubble, until on becoming too large it broke away and came to the surface, the oil returning to its original form until another large bubble formed from the smaller bubbles collecting together. On adding H_2SO_4 many bubbles and apparently the excess of the oil left the minerals, and on standing or on heating, the minerals, quartz, calcite, and gypsum became practically free from bubbles. The sulphides, metals and garnet still had the bubbles collected on them, but in a different form, each bubble being separate, and not combining with the others to form one large bubble under the surface of the oil as was the case with water alone.

A very small amount of oil only is required to oil a considerable amount of any mineral. Some South Mine tailings weighing 20 gms. was added to water, and 1 drop (.026 gms.) oleic acid added and the mixture shaken up, and put in a vacuum flask. On reducing the pressure the whole product, metallic and non-metallic, floated to the surface. With 40 gms. only about half was raised.

In Alkaline Solutions.

On the surface.—Most minerals will float on the surface of an NaOH solution, but for a few moments only, and then become wetted and sink.

On heating.—When heated in a solution of NaOH, the minerals will not float. On adding an ammonium salt, although gas is given off, no float takes place. With some zinc concentrates that have been previously floated, a good float was obtained in an ammonium carbonate solution. With NH_4Cl a partial and non-selective float was caused. Oleic acid saponified with ammonia will cause non-selective flotation, and on adding H_2SO_4 till acid, the silicates will sink, and the sulphides remain floating. A sample of zinc concentrates would not float in NaOH, and on addition of H_2SO_4 till acid would only float after heating for a considerable time.

Under reduced pressure.—Bubbles formed on the minerals under an NaOH solution under reduced pressure, the solution

being free from air. On making acid with H_2SO_4 very few bubbles remained on any of the minerals, but more were on the sulphides than the quartz and silicates.

Behaviour of Minerals and Metals in saturated Solutions of Gases.

In water saturated with CO_2.—Copper foil and other metals and also all the minerals constituting the Broken Hill tailings will float in water saturated with CO_2, being brought to the surface repeatedly by the CO_2 bubbles. Bubbles form on all the minerals, and are not confined to the sulphides. Very few form on gypsum and fewer on the quartz than on the sulphides. On addition of H_2SO_4 no bubbles remained on the gypsum and very few on the quartz, the garnet still having bubbles attached to it. The action is similar with a saturated solution of SO_2. Hydrogen peroxide is also similar in its action to the saturated solutions. The manner in which bubbles of gas are formed in a solution is very important as regards their subsequent attachment to the minerals. A very rapid current of bubbles may be evolved, but the bubbles may not attach themselves to mineral particles, and thus may not be of any use in their subsequent flotation. Sometimes the rapid evolution of a gas is useful as in the case where flocculent masses of the sulphides are held together by gas bubbles insufficient to carry them to the surface, and the rush of bubbles to the surface getting underneath these agglomerated sulphides causes them to be carried to the surface. The condition that seems to be the best for the attachment of the gas bubbles to minerals and metals is when a saturated solution is slowly evolving bubbles of gas that are being thrown out of solution by rise of temperature, or lowering of pressure. This takes place to a certain extent in all the flotation processes where a hot solution is used, the dissolved air, CO_2, H_2S and any other gases in solution being driven out when the temperature is raised. In the case of saturated solution of gas, bubbles will form on almost anything introduced into the solution. A common example is the formation of bubbles on pieces of cork in soda water and on the sides

of a glass. On addition of acid the bubbles have a tendency to select the sulphides on which to form. Some zinc concentrates obtained from Central Mine tailings, Broken Hill, by a H_2SO_4 float were washed well, dried and then floated in water with atmospheres of different gases above the water.

The following arrangement of apparatus was used:—

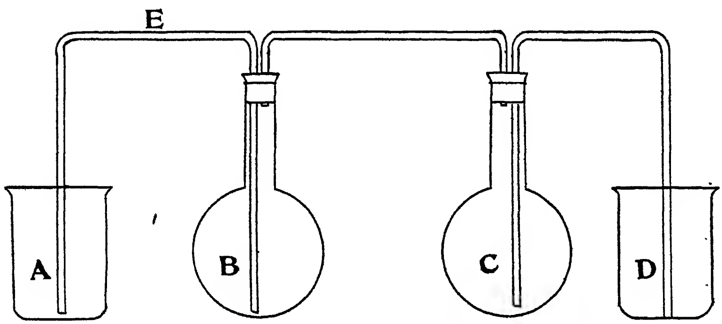

Fig. A

The zinc concentrates were placed in flask B, and boiled for a considerable time till the concentrates sank to the bottom. The flask was then filled to the top with boiling water. Flask C was filled with the gas to be used. The beaker D contained a saturated solution of the gas used, and the beaker A was half filled with air-free water. Some of the water in B was then syphoned into A, the space being taken up with the gas from C. B was then boiled, and shaken up, after closing the clamp E.

The gases tried were H_2S, nitrogen, CO_2, SO_2, oxygen, hydrogen, water vapour and air. Flotation took place in every case, the scum formed in the case of H_2S having a slightly different appearance from the others. This treatment was equivalent to boiling the sulphide in a saturated solution of the gases named, and at the same time preventing all the gas being driven off before the solution became hot.

The Action of Chlorine.

If particles of minerals are dropped into chlorine water, bubbles form on the sulphides if oiled or unoiled, fewer forming on quartz and other silicates. Under reduced pressure in chlorine water the galena and zinc blende are thickly coated with bubbles, the galena being attacked by the chlorine, since the faces rapidly tarnish. Very few bubbles come off the quartz and pyrite. A sample of Broken Hill Proprietary zinc concentrates was washed till free from soluble salts, and stood for half an hour with a dilute chlorine water solution. On analysing the solution it was found that considerable amounts of Pb, Fe, and Zn, and a lesser amount of Al had gone into solution. SO_4 was present in the solution, but no free chlorine. With these metals going into solution free sulphur must be liberated to some extent. If a sample of Broken Hill tailings is washed with Cl water it is noticed that the sulphide particles have a tendency to agglomerate and become buoyant, and are thus well prepared for subsequent flotation either by film flotation or otherwise. If a sample of tailings is shaken up with Cl water, and then a minute amount of some light oil, as petrol or gasolene, is added with a little H_2SO_4, a good flotation takes place in the cold if calcite is present to evolve CO_2. If instead of adding acid, water saturated with carbon dioxide is added, the same result is obtained. On some tailings a good flotation with Cl water and H_2SO_4 is obtained in the cold without the addition of any oil.

Film Flotation.

Film flotation is the term used to describe flotation when the mineral separated floats on the surface of the liquid to the depth of the thickness of one particle only, and not as a coherent scum as in the case of the Potter and other processes. In film processes, as the De Bavay, the sulphides, after being wetted, are brought into contact with the air, and fed on to the surface of water, and remain floating as a film and not as a scum. A sample of zinc blende obtained by film flotation

(using H_2SO_4 and oleic acid) was immersed in boiled water and boiled under reduced pressure for three hours, as much of the air being pumped out as possible. All the mineral was then on the bottom of the flask. The top of the flask was then closed. On being brought into contact with the vapour above the water, a film was again formed. When examined with the aid of a lens the film was seen to be almost entirely submerged, only fine points of the particles projecting above the surface. A film of magnetic sulphide of iron on the surface of water when attracted by a magnet drew up the surface of the water with the mineral. Copper foil will not float in air-free water under reduced pressure, but if allowed to come in contact with the vapour above the water will float, similarly to the film float obtained with minerals.

Another sample of zinc concentrates from a film float was floated on the surface of water in a flask under reduced pressure, and exhausted as far as possible by a water pump. Most of the particles forming the film sank, although the remainder persistently floated. With a lens bubbles could still be seen attached. It was frequently noticed that under reduced pressure some mineral with oil would rise to the surface in agglomerated masses, and then spread out to form a film on the surface. Sometimes a mass of sulphides clinging to a bubble on coming to the surface and the bubble bursting, the sulphides would spread out as a film, the free surface of the water taking the place of the surface of the bubble.

Action of Acids and Oils in Film Flotation.

The ores used in the following tests were freshly broken and tested as soon as crushed, so as not to allow the surface of the minerals to become altered. They were all crushed through a 40-mesh sieve, and flotation as a film was tried in water alone, with oil, and with oil, acid and water.

TABLE A.

Sample	With water alone	Oil and water	Acid, oil and water
1—Glassford Creek grey copper ore and garnet gangue	Non-selective	Non-selective	No float at all at first, but a non-selective float on long exposure to air
2—Queen Bee chalcopyrite with slate gangue	Tends to be selective	Selective till almost all the sulphide has been floated, then gangue begins to float	Selective
3—Mount Morgan pyrite and chalcopyrite	Tends to be scleetive	Similar to Queen Bee	Selective
4—Junction North ore (Broken Hill)	Non-selective	Non-selective	Selective

Effect of Tarnishing the surface of Sulphides.

If the surfaces of the sulphides are tarnished, as a rule these sulphides will not float. Taking the Horwood process as an example, the mixture of lead and zinc sulphides is given a slight roast, which is sufficient to cause the galena to become coated with lead sulphate. The zinc blende is not much altered at the low temperature at which the roasting is carried out. When the material is then heated with an oil and acid solution only the zinc sulphide floats. If galena is coated by treating with strong H_2SO_4 it has a tendency to prevent it floating; chromic acid has the same effect. Chlorine and nitric acid, which rapidly tarnish the surface of galena, do not in any way prevent flotation, but on the other hand have a beneficial effect. This may be due to the liberation of free sulphur (which does take place) on the surface of the sulphide, sulphur being one of the most easily floated substances. Some ores that will not float in their natural condition will float after being heated, the slight calcining having a beneficial effect on the flotation. This is noticeable with some of the heavy Tasmanian zinc-lead ores.

Specific Gravity of Floated Materials.

The specific gravity of some zinc concentrates from a Potter (acid) float was found to be 2.81. The specific gravity of zinc blende is usually about 4. Two other samples of zinc concentrates from a process in which oil was used had a sp. gr. of 2.55 and 2.61 respectively. The low sp. gr. noted was due to absorbed gases.

A sample of some clean crystalline galena was crushed and sifted, and 20 gms. of the material remaining on each sized sieve was taken and added to 100 c.c. water. Half a gm. of oleic acid was then added, and well shaken up with the galena. The specific gravity of each sized mineral was then taken, and resulted as follows:—

	Spc. Gr.
On 40 sieve	6.4
On 60 sieve	6.1
On 80 sieve	6.2
On 100 sieve	5.8
On 180 sieve	5.8
Through 180 sieve (partial float)	3.9

Some of the finest grained material began to float on violent shaking. The specific gravity of galena is 7.4.

The Adsorption of Gases by Minerals.

To ascertain if oxygen was absorbed from the air by an acid and oil solution with minerals, the following test was carried out:—Fifty gm. zinc concentrates were added to 200 c.c. water, and then 2 c.c. H_2SO_4 and 0.5 c.c. oleic acid was added. This solution was agitated for ¼ hour, and allowed to stand 18 hours in an airtight vessel. An analysis of the gas above the solution showed that it was composed of 14 per cent. CO_2, 18 per cent. oxygen, and 68 per cent. nitrogen. No H_2S could be detected. Blank tests were made with (1) acid, and (2) oil in the same proportion as above, the gas above the solution in each case having the composition of atmospheric air. Another test with clean galena from Broken Hill, with the

same amount of oil, acid and water, agitated for ¼ hour, showed that the gas above the solution consisted of—

1 p.c. (absorbed as CO_2).

21 p.c. oxygen.

78 p.c. nitrogen.

Lead acetate paper showed a reaction for H_2S.

With mixed magnetite and zinc blende, Mt. Garnet ore (Queensland) H_2S. could be smelt strongly. This was the case also with South Comstock (Tasmania) ore. Some zinc concentrates from Central Mine (Broken Hill) tailings obtained from an acid float, and agitated in a similar solution to the other tests, showed that the gas above the solution contained CO_2 2.2 p.c., and oxygen 19.8 p.c.

Collection and Analysis of Gases evolved from Wetted Minerals.

As it seemed apparent that some gas or gases were still retained on minerals after being wetted with water, it was decided to collect and analyse the gas. This was carried out in the following manner:—The mineral being examined was wetted with distilled water that had been freed from dissolved gases by continued boiling, and was placed in a flask provided with gas-tight connections and connected to a vacuum pump. The flask was immersed in water, which could be heated when required. The gas collected was trapped in portion of the apparatus, and transferred to a gas burette designed to hold and measure small quantities of gas accurately. In the case of minerals, the samples selected were all clean, unaltered and in most cases cystalline fragments, ground to pass an 80 mesh sieve. This material was immersed in air-free water, freed from bubbles of air held mechanically, and then put in the flask as stated above. As some of the minerals floated on reducing the pressure, a small cloth filter was stretched across the end of the joint connecting the capillary tap to the flask. This helped very much in drawing off the gas, as when the sulphides expanded on heating they completely filled the flask, and with the aid of the vacuum pump the cloth acted as a filter, only allowing the gases to pass.

In the case of the products from actual flotation processes the samples of the concentrates were taken from the scum overflowing from the spitz boxes, and put into air-tight bottles in the form of a froth. The bottles were filled as nearly as possible with this scum, together with some of the solution, and kept air-tight till ready for analysis. All the bottles were found to be under reduced pressure. In some cases a sample of the gas above the solution covering the concentrates in the bottles was taken. The results are given in the table B, page (576), and showed that the oxygen content was very low in almost every case. When the zinc concentrates were being tested, the flask was filled as full as possible with the sulphide wetted by the original solution in which they had been floated. After drawing off as much as possible of this solution with a pipette, the flask was filled to the top with air-free distilled water, very little of the original solution remaining in the flask. When the concentrates are taken out of the flask, after being subjected to the reduced pressure, and boiled in water or acid solution, they will as a rule float, this treatment apparently not affecting the flotation properties of the mineral. All the samples in table B would float when heated in their own solution, or if this solution was poured off and water added.

If the sp. gr. of zinc blende is taken as 4, then 4 gms. would displace 1 c.c. of water. Therefore to float 4 gms. of zinc blende 3 c.c. of gas (neglecting its weight) would be required, and 1 gm. would require 0.75 c.c. of gas. On heating this to 100 deg. the volume would be greater, so that if less gas than 0.75 was attached in the cold solution, the mineral would still float on heating.

By collecting the gas evolved in stages it was noticed that the first portion of the gas collected was usually air, and the last to come off was CO_2, which apparently showed that the CO_2 clung more tenaciously to the minerals than did air.

In some cases if the exhausting and heating was continued till the mineral in the flask was perfectly dry, it was found that, even if several c.c. of gas had been trapped in the collecting burette, the gas went back into the flask and could not be again drawn off into the burette unless the mineral was

rewetted. This seemed to show that the dry minerals adsorb CO_2 and air. A sample of crushed dry crystalline galena was, however, not affected by passing dry CO_2 over it.

Description of Apparatus.

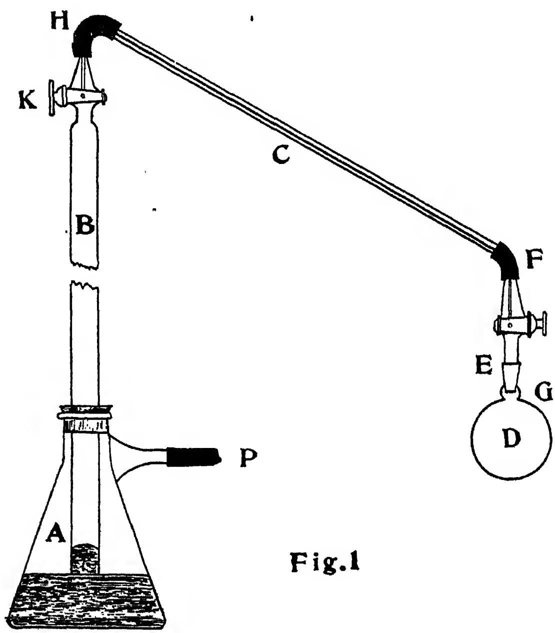

Fig. 1

A—vacuum flask with mercury.
B—100 c.c. burette 30 inches in height.
C—capillary tube.
D—glass gas tight flask 30 c.c. capacity.
E—tap and tube with ground glass joint.
F—capillary rubber joints wired on.
H— do. do. do.
G—cloth filter on end of joint E.
K—burette tap.
P—connection to water pump.

The wetted mineral is placed in flask D, and the tap and tube E is inserted after filling with air-free water. The capillary tube C is filled with air-free water, and wired on to the tap E at F. The burette B is filled with mercury by connecting to the water pump, and then the capillary tube C is wired on at H. A screw clip is also used at H for preventing air getting into tube C when the burette B is disconnected. The flask A is then connected to the water pump at P. On lowering the pressure in A, the gas in the mineral in flask D is drawn over into the burette B, where it can be caught by closing the tap K. The flask D can be immersed in a water bath and heated. The excess of water drawn over into the burette B from the flask D can be drawn off by lowering the pressure in A without allowing any of the gas to escape. Very little gas is lost in solution in the water in this manner, as the water collecting in A is under reduced pressure.

TABLE B.—*Gases collected from Concentrates from various flotation processes.*

No.	Sample	Weight gm.	Gas collectd c.c.	p. c. CO_2	p. c. N	p. c. O	Remarks
1	Zinc concentrates from process using hot acid solution	60	5.5	81.8			Put into flask without washing. Solution acid to litmus and contained ferrous sulphate
2	Zinc concentrates from process using hot acid solution	79	0.2	nil			Washed in vacuum filter till free from acid
3	Zinc concentrates from process using hot acid solution	50	2.4	83.3			Washed free from acid, washed with strong NaOH., then washed free from alkali and added 4 c.c. of a 7.5% H_2SO_4 solution
4	Zinc concentrates from a film flotation process, collected cold	49	0.7	28	58	14	This sample taken on different date from Nos. 6, 7, 8. A sample of the gas above the solution in the bottle containing this sample contained: N, 78.5%; O, 19.5%; CO_2, 2.0%
5	No. 4 sample heated to boiling and collected		2.1	95.2			
6	Zinc concentrates from a film flotation process, collected cold	46	0.9	nil	74	26	Solution neutral to litmus
7	Zinc concentrates from a film flotation process, collected cold	49	1.0	25			
8	No. 7 sample, heated to boiling	49	2.1	95			
9	Zinc concentrates from a vacumm process using oil and acid	56	1.1	81			Solution acid to litmus

TABLE B.—(*Continued*).

No.	Sample.	Weight gm.	Gas collected c.c.	p.c. CO_2	p.c. N	p.c. O	Remarks.
10	—Zinc concentrates from a hot solution oil and acid process - - - -	44	8	96.2			25 c.c. of the solution on these concentrates contained 3 c.c. of gas 90% CO_2. The gas above the solution had the following composition:—N. 75%; O, 4%; CO_2, 21%
11	—Another sample from same process as No. 10 test - - - - - -	43	6.4	96			Gas above the solution: N, 72.5%; O, 2.5%; CO_2, 25%
12	—Another sample from same process as No. 10 test - - - - - -	46	8	96			
13	—Sample from different vat from same process as No. 10 test - - - -	49	7	94			Gas above the solution: N, 78%; O, 9%; CO_2, 13%
14	—Zinc concentrates from same process as No. 10 test taken on different date -	83	4.3	92			Solution neutral to litmus. Gas above solution: N, 82°/o; O, 12°/o; CO_2, 6°/o. 75 c.c. of this solution required 1 drop NNa_2CO_3 to make alkaline with methyl orange
15	—Zinc concentrates from same process as No. 10 test taken on different date -	79	3.8	95			
16	—Zinc concentrates from same process as No. 10 test, collected in cold - -	75	0.6	41.6			
17	—No. 16 sample, heated to boiling - -	75	4.5	81			

TABLE C.—*Gases collected from different minerals under water.*

No.	Sample	Weight gm.	Gas collected c.c.	p. c CO_2	p. c. N	p. c. O	Remarks
1	Stibnite (Ringwood)	60gm	1	23.5	57	19	Sample difficult to wet
	Stibnite (Ringwood) on continuing heating and exhausting		0.2	100			The first portion collected was transferred to gas burette and the collection continued
2	Galena (Mt. Farrel, Tasmania)	124	1.1	4[illegible].9	45.4	13.6	
	Galena (Mt. Farrel, Tasmania), collection continued		0 3	100			
3	Galena (same sample as No. 2 test, exposed to air 14 days)	124	3.5	90			On boiling some of this sample with distilled water a small amount of SO_4 was found in solution
4	Unoxidised ore from Junction Mine, Broken Hill	71	1.3	84.6			
5	Pyrrhotite (freshly crushed)	63	3.2	73.4	23.2	3.4	
6	Haematite	65	0.6	nil			
7	River sand (uncrushed)	45	0.5	nil	76	24	
8	River sand (crushed to pass 120 sieve and boiled with HCl)	35	1 2	nil	75	25	
9	Block 10 Co.'s zinc tailings (coarse)	55	0.65	15.3			
10	Concentrates from a film float from Central Mine tailings	30	0.6	83			After obtaining the float by washing with oleic acid and H_2SO_4 the concentrates were well washed with H_2O
11	South Mine tailings	175	10	85			
12	Mount Garnet ore (mixed ZnS and magnetite)	110	5.4	48.1	48.1	3.7	This sample will only give a poor float, but if calcined the float is improved
13	Mount Garnet ore	117	19	90.5	8.2	1.4	Heated to 250° C. for 2 hours
14	Galena (clean sample of crystalline galena)	100	8.5	43			This sample was difficult to wet and a few bubbles of air were held mechanically

TABLE C.—(*Continued*).

No.	Sample	Weight gm.	Gas collected c.c.	p. c. CO_2	p. c. N.	p. c. O.	Remarks.
15	Galena (clean sample of crystalline galena), exhausted dry		0.4	50			This sample was put into the flask dry and heated to 100° C., and the pump connected and exhausted of air. No CO_2 was detected till most of the air had been expelled
	Galena (clean sample of crystalline galena), on further exhausting		0.25	90			
16	Galena (another sample of crystalline galena, Junction Mine, Broken Hill), collected dry	100	8	12			After exhausting as far as possible the dry mineral, the vacuum was released under air-free distilled water, which was sucked into the flask, and the latter was connected to the pump as before and the gas again collected
	Galena (another sample of crystalline galena, Junction Mine, Broken Hill), allowed to wet		2.8	100			
17	Limestone (Marmor, Queensland)	19	0.8	nil	80	20	
18	Magnesite	29	1.3	nil			
19	Dry zinc concentrates from an oil and acid float (Broken Hill)	75	2.4	33			
20	Zinc blende, crystalline specimen exposed to air 24 hours	34	0.7	57			
21	Granite (orthoclase, quartz and biotite)	25	1.5	52	29	19	
22	Chalcopyrite	67	1.6	25			
23	South Mine Lead concentrates, collected dry	117	10	5			
24	South Mine Lead concentrates, wetted		10	100			
25	South Mine Lead concentrates, collected dry	116	1.5	13			

TABLE C.—(*Continued*).

No.	Sample	Weight gm.	Gas collected c.c.	p. c CO_2	p. c. N.	p. c. O.	Remarks.
26	South Mine Lead concentrates, wetted		13	82			
27	Cerussite (Broken Hill)	50	2.7	37			
28	Copper foil cleaned with emery paper	10	0.5	nil	76	24	
29	Galena from Broken Hill cleaned with HCl	100	0.7	14			This sample of galena was a very pure sample of the mineral. It was crushed through a 60 mesh sieve and boiled for 30 minutes with dilute HCl, much H_2S being evolved. All soluble salts were then washed out and the galena was exposed to the air for 7 days, and after being wetted with air-free distilled water the gas collected as before
30	Same sample as No. 29	100	3.7	100			After exhausting the sample used in No. 29 test, the vacuum was released under a 1% acetic acid solution, 7 c.c. being drawn into the flask, which was connected to the pump, and the gas collected as before
31	Sample of galena immersed in kerosene instead of water	105	3.8	8			Remainder of gas was air
32	Broken Hill Proprietary Zinc concentrates immersed in kerosene	60	2.3	7			Remainder of gas was air
33	Cerussite (same sample as No. 27), after standing dry for 4 days	50	5	31			Remainder of gas was air. Sample very difficult to wet and held attached air bubbles
34	Galena (same sample as No. 29), after standing dry for 4 days	87	1.2	41			Remainder of gas was air
35	Coarsely crushed stick sulphur	23	2.1		78	22	

Summary.

Adsorption of Gases.

All minerals adsorb gases.

Sulphides appear to naturally absorb CO_2.

The consequence of this is—

(1) Particles are not wholly wetted when immersed in water.

(2) Particles also tend to float when sprinkled on the surface.

(3) When immersed in water and heated, the air or gases disolved in water will collect on the particles, and float or tend to float them to the surface.

(4) Saturated solutions of gases in water evolve gas which collects on all particles.

The addition of acids.—Metallic particles, such as sulphides and metals, when immersed in dilute acid solution, are not wholly wetted, but particles of rock materials become more readily wetted, and give off their adsorbed gas. When different dry minerals are sprinkled on the surface of dilute cold acid, the tendency for them all is to float as in water. The minerals are more readily wetted by hot acid solutions than cold.

The addition of alkalis.—When different mineral particles are immersed in an alkaline solution, they tend to part with their adsorbed gases, and will not float even when heated. When sprinkled dry on to the surface of the solution, they remain for a few seconds only, and then break through.

Flotation of Sulphides.

This is due to the property possessed by minerals of collecting gases on their surface, in such quantity as to diminish the density of the product, to less than that of the liquid. By calculation from the decrease in density it is found that the amount collected on dry sulphides is sometimes half the volume necessary to float them at ordinary temperature. Given a starting point, any gas generated in or introduced into the solution will tend to collect on the surface of the particles. If acid is added, the gases will leave the gangue particles and collect on the sulphides; the latter, therefore, tend to float and the former to remain under the surface of

the liquid. When substances in the solution, such as carbonates, are attacked by acids, the gases evolved saturate teh liquid, and commence to grow on the sulphides. Sulphuretted hydrogen, steam, air, and any other gases present either in the solution, introduced into it, or evolved from the minerals present, assist flotation, provided the sulphide particles have dry points on them for the gases to become attached to. Some sulphides naturally adsorb gases, and such sulphides readily float. The bulk of Broken Hill ores may be taken as examples. Other ores require preliminary treatment, so as to alter their surface to some extent. This may be done in certain cases by merely heating to 250 deg. C., or immersing in some solution which will attack the sulphides, such as nitric acid or chlorine solution. Sulphides which condense or adsorb gases well will gather together in a solution as flocculent masses, while those that do not, remain individually distinct, like grains of sand.

In certain cases sulphides will float in acid solution at ordinary temperature, but for the most part with dilute acid solution, flotation starts at about 80 deg. C. The explanation put forward that flotation at that temperature is due to certain carbonates, such as rhodochrosite, siderite, smithsonite being attacked and giving off CO_2, does not appear to be correct, for under reduced pressure these minerals are attacked but flotation does not take place. The presence of silicic acid and sulphur, as stated by De Bavay as necessary for a coagulum, is not necessary in many cases of successful flotation. When minerals are treated with dilute acids, and then exposed to the air, certain sulphides adsorb gases on their surface. If they are alternately wetted and exposed to the air, they will become entrapped by the surface film of water which they are brought in contact with. The appearance of the film is the same as that of a bubble of gas under the surface of a solution with sulphides attached. The sulphides in both cases adhere to the surface film of the bubble or free surface of the liquid, but are mainly below the surface itself. The gas obtained in all cases from experimental work and also from samples obtained from various flotation plants was CO_2, with varying quantities of nitrogen and oxygen. There is no doubt that

most of this gas is generated from gangue particles in the ore, and being more soluble in the liquid than the other gases, collects readily on the surface of the sulphides.

In all experiments with sulphides carbon dioxide was obtained on exhaustion. This gas must have been present either in the form of a compound easily decomposed by heating or by reducing the pressure, or as a gas condensed on the surfaces of the sulphides, and there retained with greater force than other gases present. It was found that the carbon dioxide was the last gas to come off.

The effect of oils.—The effect of oils has long been known in protecting minerals from being wetted by water owing to the oiling of their surfaces, and also the affinity of oils for metals, and many metallic substances. Nearly all the minerals tried could be coated with oil either in the presence or absence of water. This seems to be connected with the adsorption of gases on the particles themselves, for if the particles are deprived of their gas, then as a rule they do not become coated with oil. It would therefore appear that the oiling of particles is dependent on their gaseous attachments. If the particles are oiled to a minute extent, the gases previously adsorbed are retained, and if a solution is heated more gas will become attached to the particles, and flotation will ensue. An oil float may be obtained without acids. Nearly all minerals will float on water after being oiled.

The flotation is apparently due partly to the lesser density of the oil and the presence of gases adsorbed on the minerals or entangled in the oil. If a large quantity of viscous oil is used gases become entangled in it, and the product is oily. In course of time the particles will drop away from it, carrying down attached globules of oil. When a lesser amount of oil is used the product becomes a coherent mass like putty, showing no apparent tendency to float. On further decreasing the quantity of oil, the product becomes firmer, and breaks up into rounded pellets. With a still less quantity of oil, when shaken up with water in presence of air the product becomes flocculent, and increases in volume. This flocculation is due to the adsorption of gases. With very minute quantities of oil the flocculation becomes more pronounced, and the tendency to

float becomes greater. These results may be obtained with gangue and metallic substances. Gases collect more readily on oiled than on unoiled particles.

The effects of acids on oiled particles.—The addition of acid causes a more selective action. If oiled gangue and metallic particles are immersed in water, and acid is added, then the oil will tend to leave the gangue particles and become attached to the sulphides. The action of the oil in this respect is similar to that of the gases attached to different minerals, and probably is due to the same cause.

If an ore is treated with an acid and the acid is removed, then if the particles are oiled, the oil tends to become attached to the sulphides only. This is probably due to the removal of the gas from the gangue, which prevents oiling of the same. If acid and oil are added together, the action of the oil is selective, as in the previous case. The presence of oil on their surface does not prevent the minerals being attacked by acids.

The amount of acid required for selective flotation depends on the composition of the ore, the temperature and the pressure existing at the time. Generally it may be stated that an increase of acid will give a purer sulphide product, but flotation will take place at a lower temperature, and with a lesser amount of acid, with oil and acid than with acid alone. A selective flotation can be obtained in some cases by treatment with a chlorine solution previous to the addition of oil, and without the addition of acid.

Some of the light volatile oils will cause flotation in an acid solution at a lower temperature than the heavier and thicker oils. With some Broken Hill tailings a flotation takes place at ordinary temperature with sulphuric acid and a volatile oil.

Effects of oils and alkalis.—Flotation can be obtained in alkaline solutions when oil is used, but in every case tried the action was non-selective. On making the solution acid the action becomes selective, only the sulphides floating.

The flotation of mineral particles appears then to depend on the particles having gas attached to them becoming entangled, or caught, by the surface film of a liquid. This film may be (1) the free surface of a liquid, (2) the surface of a

bubble of gas under the surface of a liquid, or (3) the surface of a bubble of gas above the surface of a liquid. Once the particles are entangled in this film they are sustained there. That a considerable weight may be supported by this surface film is shown by the experiment of floating fine-grained mineral on the surface film of water.

The writer is much indebted to Mr. Donald Clark, of the Melbourne University, for the interest he has taken in the work and for his many suggestions and help in procuring samples. He also desires to acknowledge the help of Mr. T. J. Greenway, of the Potter Sulphide Company, for his help in procuring samples, etc. Much information and help by suggestion was obtained from Swinburne and Rudorf's paper, already referred to.

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Art. XXXVIII.—*Protozoa Parasitic in the Large Intestine of Australian Frogs, Part I.*

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(With Plates XCIV.-XCV.).

[Read 8th December, 1910].

The following investigation was carried out at the suggestion of Professor Spencer, whom I wish to thank for his help and advice. It is an endeavour to record the different protozoa parasitic in the large intestine of our Australian Frogs, and to see how they compare with those in European species. So far I have obtained for examination only five species—viz., *Hyla aurea*, *H. ewingii*, *H. peronii*, *Limnodynastes dorsalis* and *L. tasmaniensis*, but I hope before long to have other species for investigation.

In examining the contents of the large intestine I have followed largely the methods employed by Dobell (4, 5, 6, 7, 8) in his papers on the protozoa parasitic in European forms. The contents have been kept in a 0.5 per cent. salt solution containing egg albumen and I have thus been able to keep the protozoa alive for several days. For fixing I have used chiefly Schaudinn's corrosive sublimate (hot), and for staining Heidenhain's iron haematoxylin with or without eosin, picro-carmine, acetic acid alum carmine, and acid haematoxylin.

I will now proceed to enumerate the different forms of protozoa present.

A. Ciliata.

Two forms that I have always found to be very abundant in the intestine are *Nyctotherus* and *Opalina*. These are present in varying proportions in the different frogs, but gene-

rally speaking the *Opalinae* are in greater numbers. Only very rarely are they ever completely absent, and then it seems to be owing to the lack of food material in the intestine. Taking the *Nyctotherus* first, the following is an account of the species represented in the large intestine.

Nyctotherus cordiformis, Ehrenberg.

This measures on an average $213\mu \times 128\mu$, but larger and smaller specimens are also present. In three of the species of frog examined—viz.: *H. aurea*, *H. ewingii* and *H. tasmaniensis* a very large form of Nyctotherus is present, sometimes, but rarely, in great numbers. This I take to be the same species, but of an abnormally large size, measuring on an average 398 μ long and 255 μ broad, and appearing quite giant in size as compared with the others (Fig. 4). Figure 5 shows one of these with a small individual inside it which thus enables us to see how very much they differ in size. I might here mention that individuals of extreme size as compared with the normal have been observed in other groups of the Protozoa. Thus Dobell (4) records the presence in *Trichomastix serpentis* of giant forms when he says: "An individual, instead of dividing when it reached a certain size, continued to grow. In this way giant individuals arose which reached the enormous length of 30 μ, i.e., about twice the normal length." These, however, were involution forms which were produced through overfeeding, whilst my remarkably large forms are present in the intestine living under normal conditions. They may, however, have been produced in much the same way by over-feeding.

A peculiar structure visible in some of the normal specimens stained in Heidenhain's iron haematoxylin is a backwardly directed flagellum (Fig. 2) running down from the posterior end of the oral groove and then curving forwards towards the entrance to the cytopharynx. This is very definite in these preparations but does not show up with other stains. I can find no reference concerning it anywhere, unless I regard Saville-Kent's long, stiff and outwardly projecting seta of this

species as corresponding to it. He figures this in his "Manual of the Infusoria" (vol. ii., plate xxix., fig. 4) from Stein, and describes the widened entrance or vestibulum to the pharynx as "bearing on its lower edge a single long, stiff seta." This is figured also in Bronn's Klassen und Ordnungen des Thier-Reichs (I. 3. Protozoa, plate 66, figs. 5a and 5b). Some six or eight individuals show this very clearly, though in most of them it is smaller than the one figured. With iron-haematoxylin alone, the nucleus, oral groove and flagellum appear black (Fig. 2), but when double stained with eosin they are not so sharply marked, the flagellum rarely being visible. Double-stained with orange G, it is clearer than with eosin.

In Fig. 1 the position of the macro-nucleus is shown, but I have never once been able to distinguish a micro-nucleus, and after having used all the usual stains I can definitely state that there has been none present. Occasionally the animal at first sight appeared to have a small nucleus in the position in which one would expect the micro-nucleus to be, but on further examination it has proved to be some foreign body lying on the outside of the animal. In Calkins' Protozoa (page 188) we read: "The functions of the two nuclei are supposed to be respectively vegetative and reproductive (Butschli), but this distinction is perhaps too sweeping. Julin ('93) held that the macro-nucleus stands not only for nutrition, movement, sensation and regeneration, but for asexual division as well, in fact is a 'somatic nucleus,' while the micro-nucleus functions only as a sexual nucleus." On this ground therefore it might be possible to account for the absence of the micro-nucleus, for the only form of reproduction I have observed as yet is the simple transverse division (Fig. 3), which function we thus see may be carried out in the absence of the micro-nucleus.

Among the *Opalinae* there are three forms represented, one of these the commonest, i.e., the one most often present and in greatest numbers, is *O. intestinalis* (Stein). A detailed description of this well-known form is unnecessary, but the chief points I have noted are as follows:—It measures from 107 μ to 214 μ in length and is ciliated equally all over, the cilia being very large. The nuclei are spherical and placed in the

anterior third of the body. They do not show the thread-like structure connecting them which is shown in Metcalf's figure (12). The chromatin material is gathered into masses around the periphery of the nucleus. Ectosarc and endosarc are clearly distinguished, but I have not been able to make out any excretory organs (Fig. 6). Very small forms occur along with these, and I think these represent the younger individuals of the same species, for they seem to graduate up to the adults in size. This species I have found in *H. aurea*, *H. ewingii* and *Limnodynastes dorsalis*.

Degeneration in these forms took place soon after they were removed from the host. First of all the body gradually altered its shape by the swelling up of the ectosarc and became more and more spherical. After a while the ectosarc and endosarc merged into one another and became indistinguishable. The cilia gradually ceased moving and ultimately the body began to disintegrate and was attacked by countless bacteria.

Opalalina binucleata, n. sp.

This is found in great numbers in *Limnodynastes dorsalis*, and on one occasion I met with it in *Limnodynastes tasmaniensis*. It is a broad, flat form with two nuclei, and is ciliated equally all over its surface, the cilia being arranged in longitudinal rows as in other Opalinae. It is broader and more bluntly pointed at the posterior end than at the anterior (Fig. 7) and moves along with the anterior end foremost. Its usual position when swimming along is on either flat surface, but as it proceeds it occasionally rolls over from side to side. The average length is 157 μ and the average breadth 100 μ, but larger and smaller individuals have been met with. When the animal turns over and presents itself edge on, it is seen to be very thin as compared with its breadth (Fig. 8), and in section would appear flat and oval. Metcalf (12) divides Opalinae into the following groups:—

(1) Species with two nuclei, bodies circular in cross section.

(2) Species with many nuclei, body circular or broadly oval in cross section.

(3) Species with many nuclei, body flattened.

To these we may now add—

(4) Species with two nuclei, body flattened. The nuclei measure 20 μ across, and are circular in outline, and placed obliquely behind each other. The chromatin material is scattered about in masses and is not arranged in any definite order. There is no differentiation into ectosarc and endosarc visible from a general surface view, and the protoplasm appears vacuolated. During movement the posterior portion of the body shows a rigid or rucked appearance as indicated in Fig. 9, so that it seems to be contracted towards this end, and in this way it moves along.

Opalina hylarum, n. sp.

Occurs in *Hyla aurea* only, and is distinguished from all the other binucleated forms which are circular in cross section by its enormous size. It measures on an average about 420 μ, but some individuals measuring as much as 572 μ have been met with. The average breadth is 70 μ. The body is elongately oval with a rounded anterior end and a slightly rounded posterior extremity, i.e., it does not taper to a point posteriorly. The protoplasm is granular, and ectosarc and endosarc are clearly distinguishable right to the posterior end. A very well-marked feature of this species is the position of the nuclei, for they are placed very far apart, the hinder one being in the posterior half of the body. (Fig. 10.) The chromatin material is gathered into masses arranged around the periphery of the nucleus. This is well shown in the transverse section represented in Fig. 11. The body is ciliated round its entire surface, the cilia at the anterior end being slightly larger than those towards the posterior end, but there is no posterior portion devoid of cilia (Fig. 15).

Some individuals showed only a single nucleus, in different stages of division, but these are the results of recent longitudinal division. In Figs. 12 to 14 the outlines of three specimens are shown with the positions of the nuclei indicated. In Figs. 12 and 13 the daughter nuclei have not yet separated,

while in Fig. 14 division of the nucleus is completed and the nuclei have taken up their adult position.

In the posterior portion of the body excretory organs are present in the form of a great number of vacuoles, forming quite a network and extending from about the middle of the body to the posterior extremity. (Figs. 10 and 15.)

B. Flagellata.

The commonest flagellate form present in the intestine is one which I take to be identical with the *Euglenoidina* from *Rana temporaria* and *Bufo vulgaris* described by Dobell, viz., *Copromonas subtilis*. It is found in countless numbers in cultures that have been standing for some days, and is present in all the species of frog examined. On account of its small size I have not been able to make out all the minute details of structure, nor have I traced through the different stages of its life history, but its general form and movements agree so closely with *Copromonas subtilis* that I think we may say it is identical (Fig. 16). A few individuals were observed undergoing longitudinal division (Fig. 17), and also some in conjugation (Fig. 18).

Occurring along with these but in far smaller numbers is a similar form which is more rectangular in outline and slightly longer. I have not succeeded in obtaining any of these mounted on the slide, but in the living state they appear very similar in structure to the oval forms.

The other flagellate forms present in the large intestine are the trichomonads. These I have found in large numbers in four out of the five species of frog examined, there being none in *Hyla ewingii*. This need not mean, however, that they are absent in this species altogether, for I may have missed them in examining the culture, or they may have been absent only from the particular individuals under inspection. Dobell (7) says as regards the trichomonads: "It has hitherto been universally supposed that but one trichomonad occurs in frogs, namely *Trichomonas batrachorum*, Perty. There are, however, in reality two, a *Trichomonas* and a *Trichomastix*." The latter is represented by *Trichomastix batrachorum*, Dobell, which he goes on to describe.

Both these forms I can say are present in the frogs I have examined, occurring sometimes together, sometimes separately, though it has often been difficult to distinguish between them, and at times quite impossible. The main difference between the two is the presence of an undulating membrane in *Trichomonas* in place of the posterior flagellum of *Trichomastix*, otherwise a description of the one would hold good for the other also. The body has an average length of about 12 μ and is oval, or spindle-shaped. The protoplasm is clear, excepting for the food granules at the posterior end and the nucleus at the anterior (Figs. 19 to 22). The axostyle is sometimes visible as a clear rod running through the body and projecting at the posterior end, giving the body a spindle-shaped appearance; at other times it seems absent altogether and the body then assumes an oval shape. Its form changes, however, very rapidly and becomes amoeboid, and it is in this amoeboid stage in particular that the two trichomonads appear so alike, and in fact are quite indistinguishable from one another. A remarkable form of movement was shown by one individual which appeared to be in a dying condition. A peculiar elongated process was forced in and out by sudden contractions and expansions. The whole body was amoeboid and the process looked as if it might have been either the undulating membrane drawn out from the body, if it was a *Trichomonas*, or the flagella fused to the body and then extended, if a *Trichomastix* (Fig. 23).

A somewhat similar movement was observed by Dobell in *Trichomastix serpentis*.

In the fresh forms the axostyle is sometimes swollen out near its posterior end as represented in Fig. 22, and this may appear to become confluent with the body when the central portion of the axostyle is disappearing.

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EXPLANATION OF PLATES XCIV.-XCV.

In all figures

A.N. = Anterior nucleus.
ECTO. = Ectosarc.
ENDO. = Endosarc.
EXCR. = Excretory Organs.
M.N. = Macro-nucleus.
P.N. = Posterior nucleus.

Fig. 1.—*Nyctotherus cordiformis*, showing macro-nucleus.

Fig. 2.—*Same*, stained with Heidenhain's iron haematoxylin, showing peculiar backwardly projecting flagellum at end of oral groove. Drawn with the camera lucida.

Fig. 3.—*Same*, undergoing transverse division, showing macro-nucleus dividing. Drawn with the camera lucida.

Fig. 4.—*Same*, drawn with the camera lucida to show the relative sizes of the giant form, Fig. 4a, and the normal form, 4b.

Fig. 5.—Outline of *same*, showing small form inside giant form.

Fig. 6.—Diagram of *Opalina intestinalis*, showing cilia all round, ectosarc and endosarc, and rounded nuclei.

Fig. 7.—Diagram of *O. binucleata*, showing anterior and posterior nuclei, cilia, and vacuolated protoplasm. Drawn with the camera lucida.

Fig. 8.—Drawing of a living *O. binucleata* as it appears when swimming edge on.

Fig. 9.—Drawing of *same*, showing ribbed appearance at the posterior end.

Fig. 10.—Drawing of *O. hylarum*, showing position of nuclei, ectosarc and endosarc.

Fig. 11.—Transverse section of *same*, showing arrangement of chromatin material in the nucleus.

Figs. 12 to 14.—Outlines of three specimens of *same*, showing different positions of nuclei. In Figs. 12 and 13 the nucleus is dividing; in Fig. 14 nuclear division is completed and nuclei have taken up their adult positions.

Fig. 15.—Drawing of *same*, showing excretory organs.

Figs. 16 to 18.—Drawing of *Copromonas subtilis*. In Fig. 16 the adult form is shown; in Fig. 17 longitudinal division; in Fig. 18 conjugation.

Figs. 19 to 22.—Trichomonads. Figs. 19 and 20 represent *Trichomonas batrachorum*, and Figs. 21 and 22 represent *Trichomastix batrachorum*.

Fig. 23.—Diagram to show peculiar movements of a dying Trichomonad.

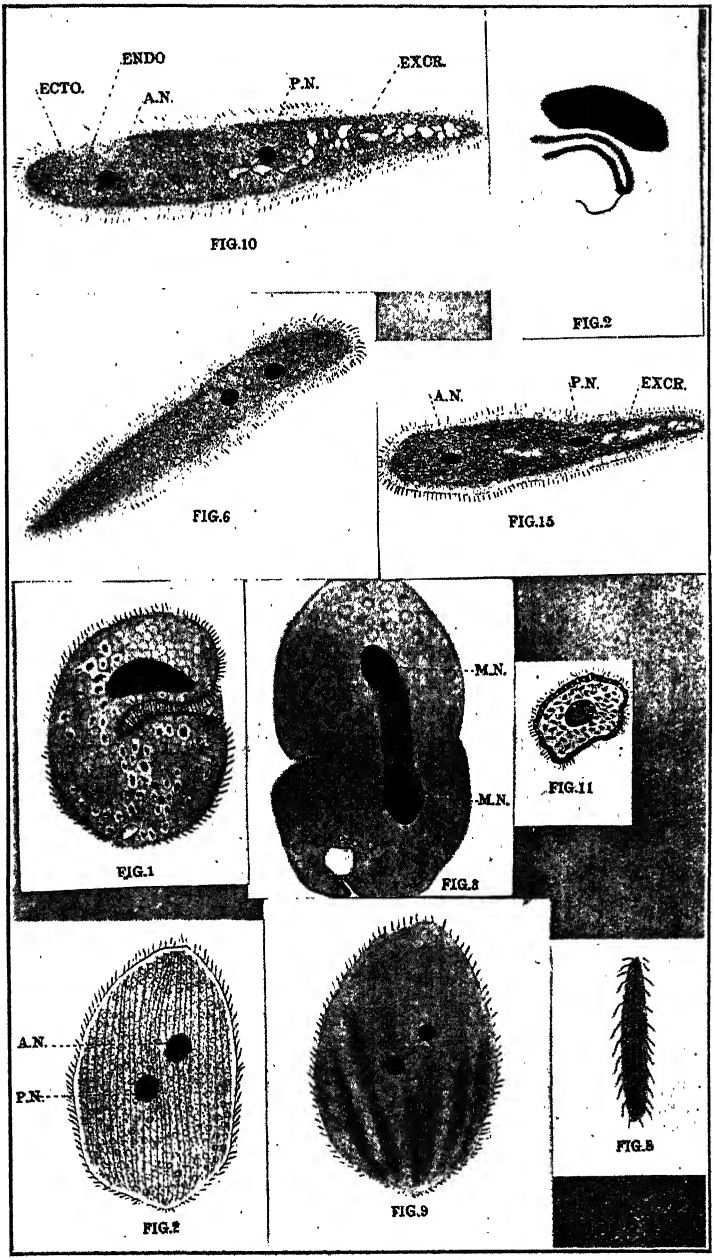
ENDO
ECTO.
A.N.
P.N.
EXCR.
FIG.10
FIG.6
A.N.
P.N.
EXCR.
FIG.15
FIG.1
M.N.
M.N.
FIG.8
FIG.11
A.N.
P.N.
FIG.9

FIG.5

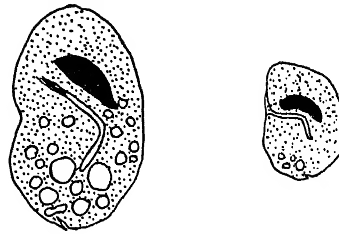

FIG.4

FIG.12

FIG.13

FIG.14

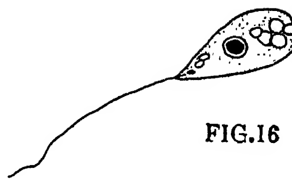

FIG.16

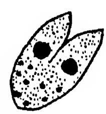

FIG.17

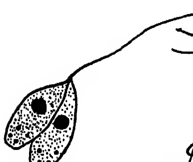

FIG.18

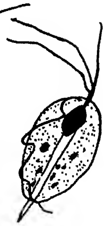

FIG.19

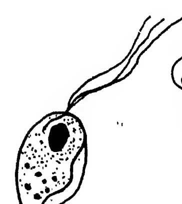

FIG 20

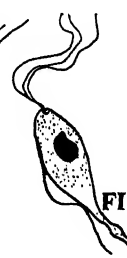

FIG.21

FIG.22

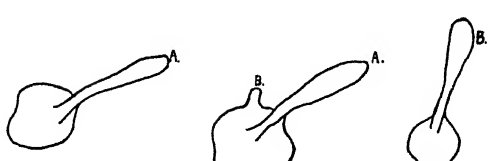

FIG.23

ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR, 1910.

The Council herewith presents to Members and Associates of the Society the Annual Report and Details of Receipts and Expenditure for the year 1910.

The following Meetings were held:—

March 10th.—Annual Meeting and Election of Officers. At the close of the Annual Meeting an Ordinary Meeting was held. Papers read: 1. "On the Growth and Habit of Biporae," by C. M. Maplestone. 2. "On Some Pselaphidae of the Howitt Collection," by Arthur M. Lea. 3. "A Species of Argas, Apparently New to Science," by Georgina Sweet, D.Sc. 4. "Strongyles in the Abomasum of Cows," by Professor J. A. Gilruth, M.R.C.V.S., F.R.S.E., and Georgina Sweet, D.Sc. 5. "Note on the Presence of Spirochaetes in the Blood of Fowls, and in Tumours of Pigs in Victoria," by Professor J. A. Gilruth, M.R.C.V.S., F.R.S.E. 6. "Notes on a New Protozoan Parasite in Sheep," by Professor J. A. Gilruth, M.R.C.V.S., F.R.S.E.

April 14th.—Mr. Victor Nightingall delivered a lecture on "An Automatic System of Wireless Telegraphy." The lecture was illustrated by experiments and lantern slides.

May 26th.—Papers read: 1. "A Haemogregarine in the Blood of Varanus varius," by Prof. J. A. Gilruth, D.V.Sc., M.R.C.V.S., F.R.S.E. 2. "Observations on the Guttural Pouches of the Horse," by Dr. W. Stapley, M.R.C.V.S. 3. "Association of Alga and Fungus in Salmon Disease," by A. D. Hardy, F.L.S. 4. "New or Little-known Victorian Fossils in the National Museum," Part XI.—"On an Impression of a Bird's Feather in the Tertiary Ironstone of Redruth, Victoria," by F. Chapman, A.L.S. Exhibits: Dr. Stapley showed dissections to illustrate the guttural pouches of the horse. Mr. Hardy showed microscopic specimens in illustration of his paper. Mr. Chapman showed ironstone cast of bird's feather and associated leaves from Redruth.

June 9th.—Papers read: 1. "A new species of Cellepora, from the South Australian Coast," by C. M. Maplestone. 2. "Observations on Parmularia obliqua and a Fossil Species," by C. M. Maplestone. 3. "Modern Improvements in Rock-slicing Machines," by H. J. Grayson. 4. "Notes on the Geology of the Country About Anglesea," by T. S. Hall, M.A., D.Sc. Exhibits: Mr. P. de J. Grut showed some photographs taken on the Victorian Eclipse Expedition to Cape York, 39 years previously. Mr. Chapman exhibited some reputed mummy peas which had been sent him by Professor J. W. Judd.

July 14th.—Mr. R. T. Baker, F.L.S., Director of the Technological Museum, Sydney, delivered a lecture on "The Australian Pines: A Technological Study," which was illus-
" The Australian Pines: A Technological Study," which was illus-
trated by lantern slides and specimens. The following papers were read: 1. "Notes on Blood Parasites," by Professor J. A. Gilruth, M.R.C.V.S., D.V.Sc.; S. Dodd, F.R.C.V.S.; and Georgina Sweet, D.Sc. 2. "Some New and Unrecorded Endoparasites from Australian Fowls," by Georgina Sweet, D.Sc., Melb. 3. "On Some New Species of Victorian Marine Mollusca," by J. H. Gatliff and C. J. Gabriel. 4. "Additions to the Catalogue of Marine Shells of Victoria," by J. H. Gatliff and C. J. Gabriel. 5. "Contributions to the Flora of Australia, Part XV.," by Professor A. J. Ewart, Jean White, D.Sc., and Bertha Rees. 6. "Note on a supposed Nematode in the Circular Muscle of an Earthworm" (*Diporochaeta grandis*), by Gwynneth Buchanan, M.Sc. 7. "Australian and Tasmanian Coleoptera Inhabiting or Resorting to the Nests of Ants, Bees and Termites," by Arthur M. Lea, F.E.S.

August 11th.—A special meeting was held, at which the Laws of the Society were revised. At the close of the special meeting an ordinary meeting was held. Professor J. A. Gilruth delivered a lecture, "The Relationships of Micro-parasites and Disease." Mr. J. J. Fenton exhibited and explained a new Calculating Slide Rule.

September 8th.—Mr. T. Griffiths Taylor, B.A., B.E., B.Sc., F.G.S., delivered an illustrated lecture, "The Glacial Geology of the Swiss Alps."

October 13th.—Papers read: 1. "On the Systematic Position of the Species of Squalodon and Zeuglodon described from Australia and New Zealand," by T. S. Hall, M.A., D.Sc., 2. "Further Descriptions of the Tertiary Polyzoa of Victoria, Part XI.," by C. M. Maplestone. 3. "Contributions to the Flora of Australia, No. 16," by Alfred J. Ewart, D.Sc., Ph.D., Jean White, D.Sc., and Bertha Wood, B.Sc. 4. "New or Little-known Fossils from the National Museum; Part XII.—On a Trilobite of Upper Cambrian Age (Olenus Series) in N.E. Gippsland, Victoria," by Frederick Chapman, A.L.S. Mr. Chapman showed the fossils dealt with in his paper, and Professor Skeats showed minerals and rocks from the same area.

November 10th.—Papers read: 1. "The Magnetic Properties of 'Stalloy,'" by H. R. Hamley, M.A., and A. L. Rossiter, B.Sc. (Communicated by Professor T. R. Lyle.) 2. "Morphology of the Vermiform Appendix," by Walter Stapley, M.D., M.R.C.V.S., and J. C. Lewis, L.V.Sc. 3. "The Comparative Study of the Fibula," by Wm. Colin Mackenzie, M.D., etc. 4. "The Biochemical Significance of Phosphorus," by Hilda Kincaid, M.Sc. (Communicated by Professor W. A. Osborne.)

December 8th.—Papers read: 1. "The Structure and General Geology of the Warrandyte Goldfield and Adjacent Country," by J. T. Jutson. 2. "A Contribution to the Physiography of the Yarra River and Dandenong Creek Basins," by J. T. Jutson. 3. "The Flotation of Minerals," by Kenneth A. Mickle. 4. "The Structure of the Seed Coats of Hard Seeds and their Longevity," by Bertha Rees. 5. "Protozoa Parasitic in the Large Intestine of Australian Frogs," Part I., by Janet W. Raff, B.Sc. 6. "The Aborigines of Lake Boga," by A. C. Stone (communicated by Professor Spencer). 7. "On Some Supposed Pyritized Sponges from Queensland," by F. Chapman, A.L.S. 8. "A Revision of the Species of Limopsis in the Tertiary Beds of Southern Australia," by F. Chapman, A.L.S.

During the year 12 members, three country members and 17 associates have been elected, and three members and three associates have resigned, and one member, one country member, and one associate have died. The increase of membership is greater than has taken place for very many years.

Henry K. Rusden was a life member of the Society, and was elected in 1866, served as a member of council for many years, and acted as secretary at different times. During the past few years he was unable, owing to his age, to attend our meetings. He contributed several papers to the Society on matters of general interest. The Society owes a good deal to his energy and organising power.

Charles Graham Weir Officer, B.Sc., was elected in 1890 when still a student at the University. In conjunction with Dr. Lewis Balfour and Mr. E. G. Hogg, he wrote several papers on the Glacial Beds of Bacchus Marsh, Coimadai and Tasmania.

Andrew Anketell Henderson, M.Sc., was elected an associate in 1905. As he lived out of Melbourne he was not known to many of the members, but was a young man of much promise.

The Proceedings of the Society, volume 22, pt. 2, was published on April 14th, and volume 23, pt. 1, on August 30th. Volume 5 of the Transactions appeared on March 22nd.

Mr. F. Wisewould was gazetted a Trustee of the Society's ground on 17th April, in the place of the late Professor W. C. Kernot.

The exchange list was revised by the Council during the year, and many additions were recommended. To meet with the increased demand the edition of the publications was increased by 50 copies.

A long-needed revision of the Laws of the Society was dealt with during the year.

A digest of the papers read is now being sent to "Nature," and will no doubt be of value.

The constant increase of the library demanded more room, and book stacks were erected in the old Council room. The North-East room has been renovated and is now used by the Council. An additional bookcase has been placed in the upstairs lecture room. In spite of these additions the time cannot be far distant when the library will have outgrown present accommodation. The erection of a lecture-hall to seat about 300 people would free the downstairs meeting-room for library purposes, and would enable the Society to hold more frequent conversaziones, this being at present impossible owing to their cost.

It is to be hoped that some scheme for raising the necessary funds will be devised.

In October the National Park, Wilson's Promontory, was visited by His Excellency Sir Thomas Gibson-Carmichael, the Acting Minister of Lands (Mr. James Cameron), and most of the Members of the Committee. As a result of the visit the Minister promised to have several main tracks marked out and a certain amount of forming to be done. The ranger's house at Derby River is completed, and a small jetty in the S.W. end of Corner Basin has been erected. The posts for the fence are being carted into position. A few kangaroo, wombats, emus and lyre birds have been introduced, but the Committee's work is greatly hampered by want of funds.

The Librarian reports that during the year 1670 additions have been made to the library, and about 250 volumes have been bound. Owing to changes in the location of books the card catalogue is very defective, but it is hoped that an early revision will be made.

Royal Society of Victoria in Account with the Hon. Treas.—March 1st, 1910 to March, 1911.

RECEIPTS.

	£ s. d.	£ s. d.
To Bank of Australasia—Balance from 1909-10		£226 2 6
Subscriptions—		
Members, 1910	£108 13 6	
Arrears	15 15 0	
Associates, 1910 ...	60 7 0	
Arrears	12 1 0	
		196 16 6
Government Grant		200 0 0
Rents—		
Federal Government ...	£50 0 0	
Field Naturalists' Club	10 0 0	
		60 0 0
Sale of Books, etc.		4 4 6
		£687 3 6

EXPENDITURE.

	£ s. d.	£ s. d.
By Publishing—Printing, &c. ...	£281 12 11	
Distributing	66 18 9	
		£348 11 8
Maintainance—		
Rates	£12 17 0	
Insurance	5 1 3	
Caretaker's A/cs.	17 11 9	
Assist. Secretary's Salary	28 6 8	
Sundries—Lanternist, Gas A/cs., &c.	7 16 3	
Petty Cash, Hon. Sec. ...	2 0 0	
„ „ Hon. Treas. ...	4 0 0	
		77 12 11
Library—		
Perodicals	£6 18 0	
Binding	17 9 0	
New Book Case	30 0 0	
		54 7 0
Building—Electric Light ...	£27 15 3	
Repairs and Additions ...	42 17 4	
		70 12 7
Cash Charges—Commission	£10 19 6	
Bank Charges	0 10 0	
		11 9 6
Bank of Australasia—Balance		124 9 10
		£687 3 6

Compared with the Bank Pass-Book, Cash-Book, and Vouchers, and found correct,

(Signed) WM. A. HARTNELL,
Hon. Treasurer.

1st *March*, 1911.

(Signed) JAMES E. GILBERT,
JAS. ALEX SMITH, } *Auditors.*

Royal Society of Victoria.

1910.

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1910.

LIST OF MEMBERS

WITH THEIR YEAR OF JOINING.

Patron.

His Excellency Sir Thomas Gibson-Carmichael, Bart. ... 1908

Honorary Members.

Forrest, The Hon. Sir J., K.C.M.G., West Australia ... 1888

Liversidge, Professor A., LL.D., F.R.S., Hornton-street, Kensington, Lond. 1892

Scott, Rev. W., M.A., Kurrajong Heights, N.S.W. 1855

Verbeek, Dr. R. D. M., Buitenzorg, Batavia, Java 1886

Life Members.

Butters, J. S., F.R.G.S., Empire Buildings, Collins-street west, Melb. 1860

Eaton, H. F. 1857

Fowler, Thos. W., M.C.E., Colonial Mutual Ch., 421 Collins-street, Melb. 1879

Gibbons, Sydney, F.C.S., 31 Gipps-street, East Melb. 1854

Gilbert, J. E., "Melrose," Glenferrie-road, Kew, Vic. ... 1872

Love, E. F. J., M.A., D.Sc., F.R.A.S., Moreland Grove, Moreland 1888

Nicholas, William, F.G.S. 1864

Selby, G. W., 99 Queen-street, Melb. 1881

White, E. J., F.R.A.S., Observatory, Melb. 1868

ORDINARY MEMBERS.

Anderson, J. H., M.B., B.S., Medical School, University, Melb. 1909

Balfour, Lewis, B.A., M.B., B.S., Burwood-road, Hawthorn, Vic. 1892
Baracchi, Pietro, F.R.A.S., Observatory, Melb. 1887
Barnes, Benjamin, Queen's Terrace, South Melb. 1866
Barrett, A. O., "Melisse," Bruce-street, Toorak, Vic. ... 1908
Barrett, Dr. J. W., Collins-street 1910
Berry, Prof. R. J. A., M.D., F.R.C.S., F.R.S.E., University, Melb. 1906
Boys, R. D., B.A., Public Library, Melbourne 1903
Brittlebank, C. C., "Queensgate," St. George's-road, Elsternwick 1898

Cameron, S. S., D.V.Sc., Agricultural Dept., Melb. 1910
Cherry, T., M.D., M.S., Department of Agriculture, Melb. 1893
Clark, D., M.M.E., B.C.E., University 1910
Cohen, Joseph B., A.R.I.B.A., Public Works Department, Melb. 1877

Dunn, E. J., F.G.S., "Roseneath," Pakington-street, Kew, Vic. 1893
Ewart, Prof. A. J., D.Sc., F.L.S., University, Melb. ... 1906
Fryett, A. G., care Dr. F. Bird, Spring-street, Melb. ... 1900
Gault, Dr. E. L., M.A., M.B., B.S., Collins-street, Melb. 1899
Gillott, The Hon. Sir S., K.C.M.G.,, "Edensor," Brunswick-street, Fitzroy, Vic. 1905
Gilruth, Prof. J. A., D.V.Sc., M.R.C.V.S., F.R.S.E., University, Melb. 1909
Grut, P. de Jersey, 125 Osborne-street, South Yarra, Vic. 1901

Hake, C. N., F.C.S., Melbourne Club, Melb. 1890
Hall, T. S., M.A., D.Sc. University, Melb. 1890
Hartnell, W. A., "Irrewarra," Burke-road, Camberwell, Vic. 1900
Harvey, J. H., A.R.V.I.A., 128 Powlett-street, East Melb. 1895
Hooper, Dr. J. W. Dunbar, M.D., L.R.C.S., etc., Collins-street, Melb. 1904

Jamieson, James, M.D., 96 Exhibition-street, Melb. ... 1877
Jones, Dr. W. E., M.R.C.S., "Ludlow," Malvern-road, Toorak 1910

Kelly, Bowes, 70 Queen-street, Melb. 1910
Kendall, E. A., G.M.V.C., "Coniston," Esplanade, Middle Brighton 1910
Kernot, W. N., B.C.E., Working Men's College, Melb. ... 1906
Kershaw, J. A., F.E.S., National Museum, Melb. 1900
Kitson, A. E., F.G.S., Imperial Institute, S. Kensington, Lond. 1894

Leach, A. J., M.Sc., Education Department, Melb. 1904
Lyle, Prof. T. R., M.A., D.Sc., University, Melb. 1889
Loughrey, B., M.A., M.D., Ch.B,, M.C.E., 1 Elgin-street, Hawthorn, Vic. 1880

MacKenzie, Colin W. M.D., B.S., F.R.C.S., Collins-street, Melb. 1910
Masson, Prof. Orme, M.A., D.Sc., F.R.S.E., F.R.S., University, Melb. 1887
Michell, J. H., M.A., F.R.S., University, Melb. 1900

Nanson, Prof. E. J., M.A., University, Melb. 1875

Oliver, C. E., M.C.E., Metropolitan Board of Works, Melb. 1878
Osborne, Prof. W. A., M.B., Ch.B., D.Sc., University, Melb. 1910

Payne, Prof. H., M.I.C.E., M.I.M.E., University, Melb. ... 1910
Petherick, E. A., F.R.G.S., F.L.S., Federal Parliamentary Library 1910

Robertson, A. W. D., M.D., B.S., University, Melb. 1909
Robertson, W. A., G.M.V.C, Agricultural Dept., Melb. ... 1910
Rowe, W. C., "Invicta," Chaucer-street, Canterbury, Vic. 1908

Schlapp, H. H., 31 Queen-street, Melb. 1906
Shephard, John, Clarke-street, South Melb. 1894
Skeats, Prof. E. W., D.Sc., University, Melb. 1905

Spencer, Prof. W. Baldwin, C.M.G., M.A., F.R.S., University, Melb.	1887
Stapley, W., M.D., D.V.Sc., M.R.C.V.S., Veterinary School, University, Melb.	1910
Sweet, George, F.G.S., Wilson-street, Brunswick, Vic. ...	1887
Swinburne, The Hon. G., M.L.A., "Shenton," Kinkora-road, Hawthorn, Vic.	1905
Taylor, R., 31 Queen-street, Melb.	1907
Walcott, R. H., F.G.S., Technological Museum, Melb. ...	1897
Ware, S., M.A., Education Department, Melb.	1901
Wisewould, F., 408 Collins-street, Melb.	1902

Country Members.

Desmond, J., R.V.S., G.M.V.C., "Ellerslie," Hurtle-square, Adelaide, S.A.,	1901
Gregory, Prof. J. W., D.Sc., F.R.S., University, Glasgow	1900
Hart, T. S., M.A., B.C.E., F.G.S., School of Mines, Ballarat, Vic.	1894
Hogg, H. R., M.A., 2 Vicarage Gate, Kensington, W. ...	1890
Ingram, Alex., Hamilton, Vic.	1903
Lea, A. M., F.E.S., Government Entomologist, Hobart	1909
Maplestone, C. M., Eltham, Victoria	1898
Mennell, F. P., Rhodesian Museum, Buluwayo, South Africa	1902
Murray, Stuart, C.E., "Morningside," Kyneton, Vic. ...	1874
Oddie, James, Dana-street, Ballarat, Vic.	1882
Officer, C, G. W., B.Sc., "Kallara," Bourke, N.S.W. ...	1890
Thom, L. N., B.Sc., Shepparton, Vic.	1910

Corresponding Members.

Bailey, F. M., F.L.S., Government Botanist, Brisbane, Queensland	1880

Dendy, Professor Arthur, D.Sc., F.R.S., Sec.L.S., King's College, London 1888

Etheridge, Robert, Junr., Australian Museum, Sydney, N.S.W. 1877

Lucas, A. H. S., M.A., B.Sc., Sydney Grammar School, Sydney, N.S.W. 1895

Stirton, James, M.D., F.L.S., 15 Newton-street, Glasgow 1880

Associates.

Abbott, S. B., 22 Rowan-street, Bendigo 1910
Armitage, R. W., B.Sc., Continuation School, East Melb. 1907
Bage, Mrs. Edward, "Cranford," Fulton-street, St. Kilda, Vic. 1906
Bage, Miss F., M.Sc., Fulton-street, St. Kilda, Vic. 1906
Baker, Thomas, Bond-street, Abbotsford, Vic. 1889
Bale, W. M., F.R.M.S., Walpole-street, Hyde Park, Kew, Vic. 1887
Bennetts, W. R., Pakington-street, Kew, Vic. 1894
Barkley, H., 9 Denham-street, Hawthorn 1910
Booth, John, M.C.E., B.Sc., 25 Rathdown-street, Carlton, Vic. 1872
Brook, R. H. T. 1906
Buchanan, Miss G., B.Sc., University, Melb. 1910

Chapman, F., A.L.S., National Museum, Melb. 1902
Corbett, J., "Clifton," 39 Rushall-crescent, N. Fitzroy, Vic. 1907

Danks, A. T., 391 Bourke-street West, Melb. 1883

Fenton, J. J., 89 Royal Parade, Parkville 1910
Ferguson, W. H., 59 Brinsley-road, E. Camberwell 1894
Finney, W. H., 40 Merton-street, Albert Park, Vic. 1881
Fulton, S. W., 369 Collins-street, Melb. 1900

Gabriel, C. J., Victoria-street, Abbotsford, Vic. 1908
Gabriel, J., "Cwmdar," Walmer-street, Kew 1887

Gatliff, J. H., 32 Morrah-street, Parkville 1898
Green, W. Heber, D.Sc., University, Melb. 1896
Grayson, H. J., University, Melb. ... ..., ... 1902

Hamilton, J. T., "Brooklyn," Heidelberg-road, Ivanhoe ... 1910
Hardy, A. D., F.L.S., Lands Department, Melb. 1903
Henderson, A. A., M.Sc., Agricultural High School, Wangaratta, Vic. 1905
Herman, Hyman, B.C.E., F.G.S., 60 Queen-stret, Melb. 1897
Hoadley, C. A., "Bella Vista," Cotham-road, Kew 1910
Howitt, A. M., 32 Acland-street, St. Kilda 1910
Hunter, S. B., Department of Mines, Melb. 1908

Jobbins, G. G., Electric Lighting and Traction Co., Geelong, Vic. 1902
Jutson, J. T., "Oakworth," Smith-street, Northcote, Vic. 1902

Kenyon, Mrs. A. F., 291 Highett-street, Richmond, Vic. ... 1908
Kenyon, A. S., Heidelberg, Vic. 1901

Lambert, Thomas, Bank of New South Wales, Benalla, Vic. 1890
Lewis, J. C., L.V.Sc., Veterinary School, University 1910
Luly, W. H., Department of Lands, Treasury, Melb. ... 1896

Mitchell, S. R., Carrington-grove, E. St. Kilda, Vic. ... 1908
Maclean, C. W., "Bronte," Strand, Williamstown, Vic. 1879
Mahoney, D. J., B.Sc., "Coonal," Clendon-road, Toorak, Vic. 1904
McEwan, John, 317 Collins-street, Vic. 1898
McKenzie, G. Lands Department, Melb. 1907
McNab, V. R., "Almaden," Kooyong-road, Caulfield 1910
Miller, E. E., Boundary-road, Toorak, Vic. 1908
Moule, F. G., "Seacombe," Brighton 1910

Nicholls, E. B., 164a Victoria-street, North Melb. 1904
Nimmo, W. H. R., B.C.E., Brisbane, Q. 1908

Oliver, Miss K., University, Melb. 1910
O'Neill, W. J., Lands Department, Melb. 1903
Ower, L. H., State Coal Mine, Wonthaggi 1910

Pritchard, G. B., B.Sc., F.G.S., "Talavera," 6 Kooyong-road, Hawthorn. 1892

Raff, Miss J., B.Sc., University, Melb. 1910
Rees, Miss B., University, Melb. 1910
Richards, H. C., M.Sc., Central Technical College, Brisbane, Queensland 1909
Ritchie, E. G., Assoc. M.I.C.E., Met. Board of Works, Melb. 1909
Roberts, R. D., "Braemar," Stirling-street, Kew 1909

Sayce, O. A., Harcourt-street, Hawthorn, Vic. 1898
Schafer, R., "Invercloy," Napier-street, Essendon, Vic. 1883
Smith, J. A., 15 Collins-place, Melb. 1905
Stillwell, F. L., Ormond College, Parkville 1910
Summers, H., B.Sc., 49 Airlie-street, S. Yarra, Vic. ... 1902
Sutton, C. S., M.B., B.S., Rathdown-street, N. Carlton, Vic. 1908
Sutherland, Ian M., M.C.E., "Novar," Dandenong, Vic. 1905
Sweet, Miss G., D.Sc., Wilson-street, Brunswick, Vic. ... 1906

Thorn, Wm., Mines Department, Melb. 1907
Thiele, E. O., M.Sc., c/o O. A. Thiele, "Evandale," Chatham-road, Canterbury, Vic. 1898
Traill, J. C., B.A., B.C.E., "Osmington," Domain-road, South Yarra, Vic. 1903

Wedeles, James, 231 Flinders-lane, Melb. 1896
White, Miss R. E. J., M.Sc., Observatory Quarters, S. Yarra, Vic. 1908
Wilkinson, H. L., M.C.E., Equitable Buildings, Melb. ... 1909
Woodward, J. H., Queen's Buildings, Rathdown-street, Carlton, Vic. 1903

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The names of new genera and species are printed in italics.

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